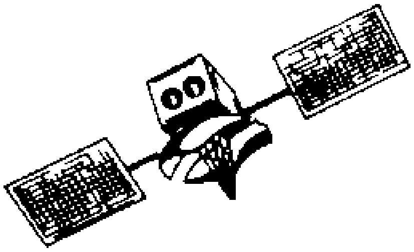

THE GIBSON SATELLITE NAVIGATOR MANUAL

...a Manual to assist you in understanding how your TVRO/ARO antenna system must be designed, constructed and operated so that your system will be able to access the full geostationary/Clarke orbit belt of satellites.

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Satellite Television Technology
P. O. Box 2476
Napa, CA 94558
and Bob Cooper, Jr.

PRICE: $30 per copy

GENERALIZED MAGNETIC VARIATION CHART FOR US AND CANADA

FIND YOUR LOCATION IN CHART. ROTATE COMPASS SO NEEDLE IS EAST OR WEST OF NORTH BY THE AMOUNT SEEN BELOW. THE 'N' SYMBOL WILL THEN BE POINTED (VERY GENERALLY) AT TRUE NORTH.

ALABAMA	2E	KENTUCKY	1E	N.DAKOTA	11E
ALASKA	26E	LOUISIANA	6E	OHIO	3W
ARIZONA	14E	MAINE	20W	OKLAHOMA	9E
ARKANSAS	6E	MARYLAND	8W	OREGON	20E
CALIF.	17E	MASS.	15W	PENN	8W
COLORADO	14E	MICHIGAN	3W	RHODE ISLAND	15W
CONN.	13W	MINN.	6E	S.CAROLINA	2W
DELAWARE	10W	MISS.	5E	S.DAKOTA	11E
WASH DC	8W	MISSOURI	6E	TENNESSEE	1E
FLORIDA	2E	MONTANA	18E	TEXAS	10E
GEORGIA	0	NEBRASKA	11E	UTAH	15E
HAWAII	11E	NEVADA	17E	VERMONT	15W
IDAHO	19E	N.H.	16W	VIRGINIA	6W
ILL.	2E	N.J.	11W	WASHINGTON	22E
INDIANA	0	N.MEXICO	13E	W.VIRGINIA	5W
IOWA	6E	NEW YORK	10W	WISCONSIN	2E
KANSAS	9E	N.CAROLINA	5W	WYOMING	13E

ALBERTA	22E	MANITOBA	10E	SASK.	17E
B.C.	23E	ONTARIO	8W	QUEBEC	17W

THE GIBSON SATELLITE NAVIGATOR MANUAL

A complete guide to designing a ground mounting system for your TVRO/ARO antenna system plus construction details on mechanical and computer driven antenna mounting systems for automating the satellite-changing function of your terminal system.

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THE COVER - Stephen Gibson of Los Angeles, California epitomizes the true private satellite terminal enthusiast. Gibson's terminal was assembled utilizing a surplus dish antenna plus a commercial LNA and tuneable receiver. His background in computer system design and programming plus his interest in celestial navigation and automated systems all comes together in this STT manual to provide the user with a complete guide to his own TVRO/ARO antenna mounting and control system. Gibson's current project is to program his TRS-80 computer so that it will cause his TVRO receiver to go into a 'scan mode' by which he can tell the computer to find for him automatically the first satellite TV carrier which is carrying the latest stock market (etc.) reports!

This manual has been produced and is being distributed by Satellite Television Technology, P. O. Box 2476, Napa, CA 94558. The price is $30 per copy and **this includes the expressed permission** of author Stephen Gibson **to all** buyers of this manual to utilize any of the electronic circuits or computer programs contained herein **for private** applications. Commercial distribution of electronic circuits (as boards, kits or wired and tested units) or of the computer program(s) in this manual is **reserved by Stephen Gibson**.

Copying This Manual - This Manual is copyrighted 1980 © by Stephen Gibson and Satellite Television Technology. This simply means that you are not authorized to slide any portion (or all!) of this manual into your handy-dandy office copying machine and run off 1 or several hundred copies for friends who are basically too cheap to invest their own money in their own manual. Like all STT manuals, **The Gibson Satellite Navigator** is the culmination of years of study and work by the author. He is willing to share his knowledge and experience with you for a modest fee approximating what you might pay for a couple of college level course credits in the local college. Considering that the material in this manual will increase the usefulness of your TVRO/ARO terminal ten fold or more, and that by employing the mechanical designs contained herein you can save yourself hundreds of dollars in your own terminal mounting and control system, we suggest that you are doing the 'right thing' by hiding this manual away from free-loading friends. **NOTE** that each original purchaser of this manual is entitled to a nominal charge geostationary/Clarke orbit azimuth and elevation pointing chart customized to your own location; a service which costs as much as $7.50 from other sources commonly available in this field. **Also note** that this manual includes a special cut-out set of navigation tools; the STT Inclinometer and the STT Sun Compass. These are tools which you can employ to make your own use of 'satellite navigation' more productive and expert.

CONTACTING STT: For additional copies of this Manual ($30.00 each) or for a complete list of more than six Manuals currently available, or for information regarding a subscription to the monthly 'journal' of the private satellite terminal industry (**Coop's SATELLITE DIGEST**), you may contact **STT** (Satellite Television Technology) at P. O. Box G, Arcadia, Oklahoma 73007 (405/396-2574).

GIBSON'S SATELLITE DISH POINTING TACTICS

Perhaps the most exciting part of getting your private TVRO working will be the moment you first receive that signal from space. It is always a thrill to swing the dish around, apply power to your receiver and fine tune the dish pointing angles in anticipation of that moment when the blast of snow and sparklies on the screen disappear and a high quality TV picture pops into view. It's almost magical but certainly a feeling of triumph to have singlehandedly brought many pieces of information and equipment together to receive signals that have traveled more than 50,000 miles to reach you.

For some, this moment is a long time coming and others it is a piece of cake. A lot of variables control how long it will take you to find a satellite, make the picture acceptable and stay locked-on as it were to the good signal you've labored so long and hard to get. Part of your success is in knowing some of the 'tricks of the trade' if you can call them tricks. They more probably should be called 'rules to follow' for success. Not much is written in the form of practical advice. Maybe we can dispel some of the confusion and show you by example how simple some elemental facts are and where to be extra careful to avoid disappointment and aggravation.

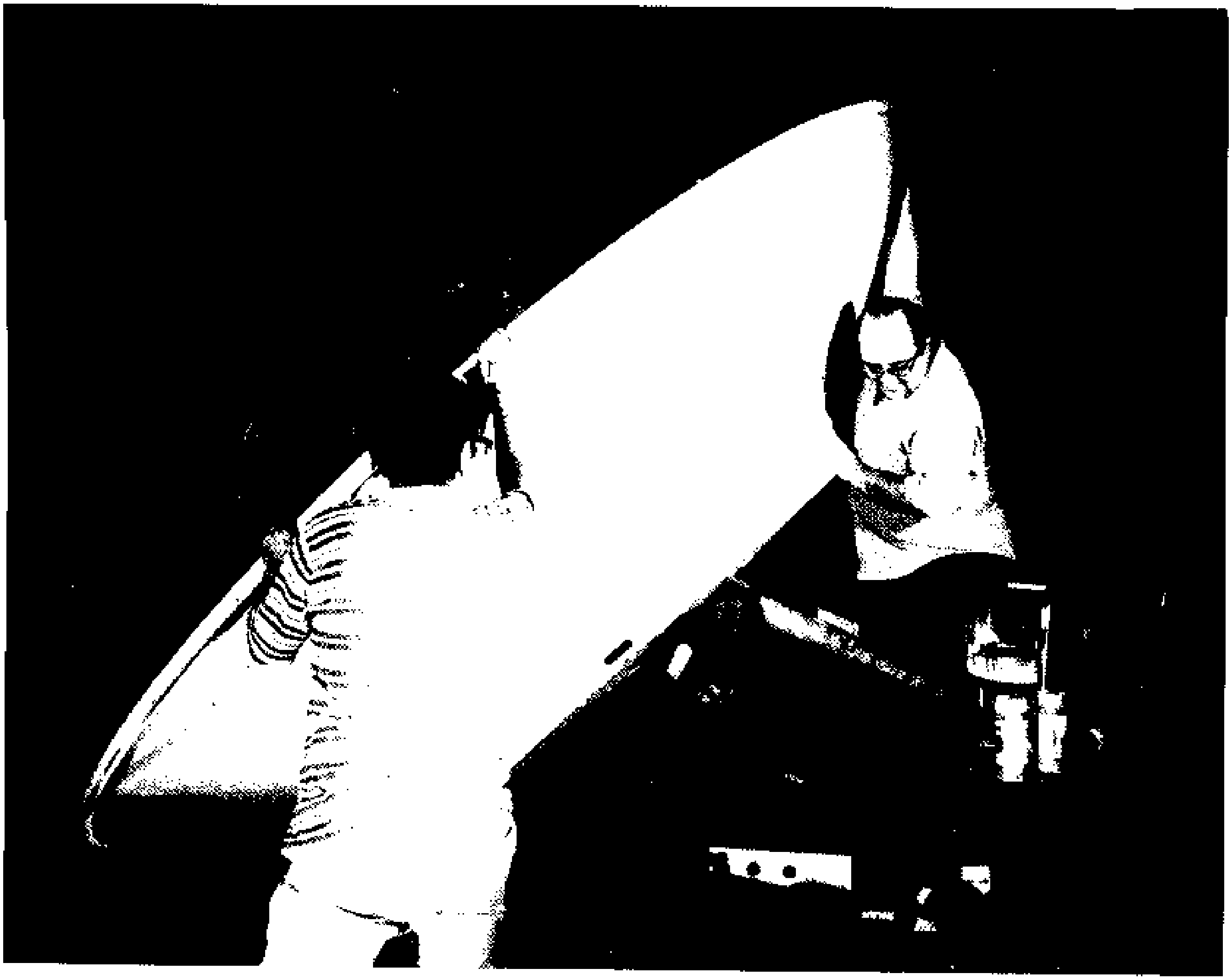
Acquisition of Signal or AOS as NASA calls it can be as simple as leaning your dish against a convenient saw horse or to the extreme of punching coordinates into a computer to automatically find the satellite. Surprisingly enough, the methods you follow to that point may be identical. The only difference between the two is a measure of constancy, repeatability and the time you wish to spend. You can certainly be content to lean the dish against the house or a child's swing set you bought at a swap meet. But you may soon want to find other satellites in as much as programming is now more than ever being spread out on several birds.

Even staying on a single satellite is not without problems. The weather will work against you. Your saw horse mount is fine until the first breeze comes along. Dishes are great sails. A whiff of air and the thing moves an inch perhaps. Not much to worry about with your 10' dish. Two inches though and the signal is gone! We're back to that measure of constancy as a factor you may need to consider as you build your station.

You can easily start with a saw horse or nearby tree as a mount and move on to something more stable to beat the wind. Even add motors to give yourself that element of repeatability we talked about so you can find other satellites and return to them again and again. In fact a computer interface complete with all the bells and whistles is easily attainable. It's all a matter of convenience and willingness to either live with annoying problems or solve them. So let's solve a few!

POINTING YOUR DISH

For many, dish pointing is an art. It doesn't have to be in



GETTING YOUR FIRST picture may be easier if you round up a few strong backs by tempting them with a six-pack!

STT INCLINOMETER [see text and page 47 this Manual] makes a quick and inexpensive way to measure antenna elevation. More elaborate inclinometers are on sale at SEARS, Wards and engineering supply firms.

as much as simple principles can be applied to achieve success. It should go without saying that you must have a clear view of the geostationary satellite belt or at least the general area of the sky you think the satellite you want is located. Pointing a dish in that direction and then moving it up and down or left and right may seem like a good idea at first, but unless you are very lucky you may change your mind after several hours of fiddling.

Let's say that you have a rabbit's foot in your pocket and chance to have your receiver tuned to a working transponder and low and behold...viola...a picture! At this point it would be a good idea to check the tilt angle the dish is situated at and perhaps it's horizontal position so you can get it 'back' if a wind comes up or if you stumble over the coax running to tell anyone who will listen and look at what you've done!

You can paste the STT cut-out inclinometer in the back of this manual onto a stiff piece of cardboard or wood and use it with a weighted string or wire pointer to get a vertical angle. Angle brackets from the hardware store can be used to mount it to the antenna with sheet metal screws. Use metal washers as shims to align the inclinometer.

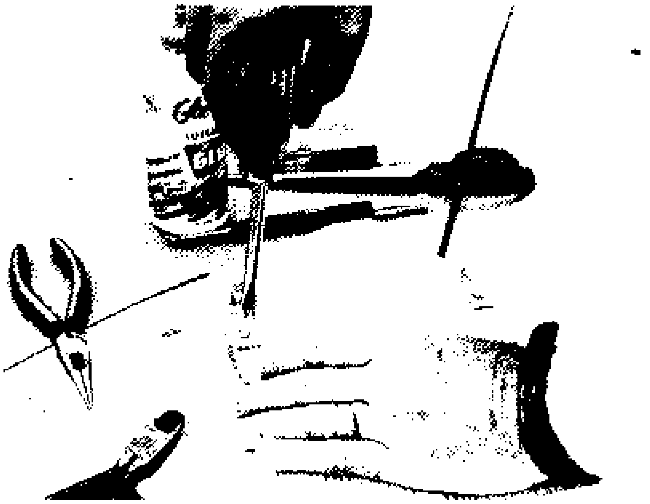
A good reference for the horizontal angle or azimuth can be any landmark or even stakes driven into the ground. A better reference would be True North. You can establish a line bearing true north from the Northern sky star map in appendix A which will help you find the pole star. Or you can use a compass to find a magnetic bearing. Just be sure to take your readings away from any metal. Use the Generalized Magnetic Variation Chart in appendix B to find True North with a compass.

X MARKS THE SPOT

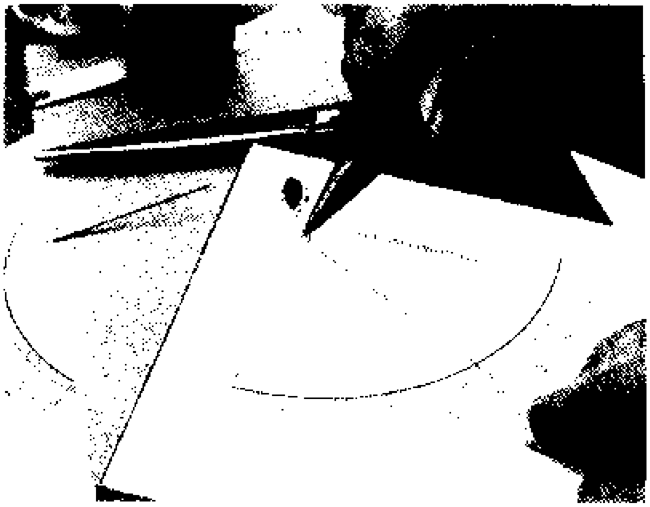
This is a good place to explain briefly what coordinates are and how we use them to find the birds. So before giving any more attention skyward, let's do a little ground work. This is easy stuff and very important if we are ever going to find a satellite with any measure of certainty.

To find a point on a map, we need to know only it's distance from a horizontal reference point and a vertical reference point. If we draw a horizontal line and a vertical line from the reference points, we've easily found a way to describe the location we seek where the two lines meet. The lines we draw are called meridians and knowing where to draw the lines is simply a matter of measuring the horizontal and vertical distances from the reference points or meridians. The reference meridians on a map are sometimes seen as faint vertical and horizontal lines as seen in **figure 1**.

Meridians are measured in degrees from the reference points. If we need to specify fractions of a degree, we break it up into minutes. One degree has 60 minutes in it. And fractions



STT INCLINOMETER - glue to piece of cardboard or wood; use metal brackets to hang on antenna. Washers under bracket will shim; use carpenter's level to align [see page 47 at rear of Manual.



STT INCLINOMETER - A weighted strong or a stiff wire hung from 'thumbtack' makes a simple angle-indicator.

of a minute are measured in seconds. 60 seconds equal one minute.

The location of the vertical reference point is anywhere along the equator seen in **figure 2**. Everyone thinks of the equator as a horizontal reference line and indeed it is. But we want to have a place to measure distances north and south and the equator is a dandy spot because it's in the middle. Points of latitude are found north or south of the equator from zero degrees (at the equator) to 90 degrees (at the poles). The way we know if a point is in the northern or southern hemisphere of the earth is to simply specify North or South. Hollywood, California is located at a point about 34 degrees **north** of the equator seen in **figure 3**.

You may be wondering how we got around to thinking of degrees as lines instead of angles. Well, they are still angles alright, but the angles are measured from a point in the center of the earth.

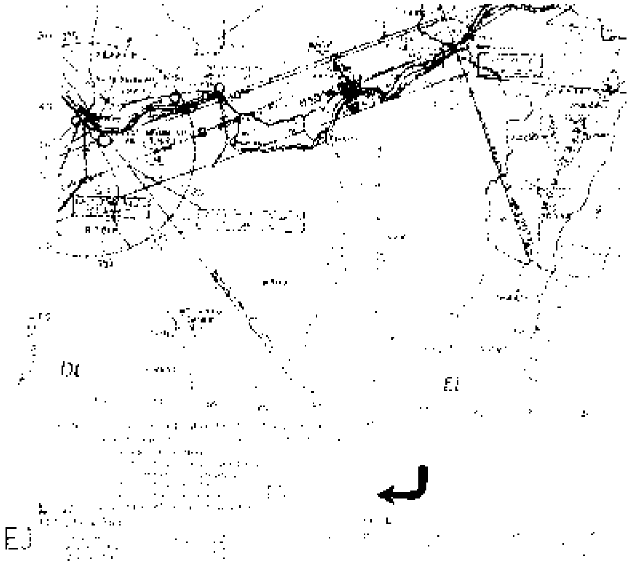
The horizontal meridians are also measured in angular degrees from the center of the earth. They are called degrees of longitude and instead of being measured north and south in the case of latitude, they are measured east and west. The reference point for zero degrees longitude is in Greenwich, England. New Orleans is 90 degrees **west** of Greenwich while Rome, Italy is about 12 degrees **east** of Greenwich; **figure 4**.

While degrees of latitude will never meet because they stop at 90 degrees at opposite poles, degrees of longitude do meet on the opposite side of the earth from Greenwich at 180 degrees. It's the International date line and all of it is in the ocean so no one is affected by the possibility of being 180 east and 180 west at the same time.

To find the position of any place on the earth, we must know both the latitude and longitude coordinates of that place. St. Louis, Missouri is located 38 degrees, 38 minutes **north** latitude and 90 degrees, 12 minutes **west** longitude in figure 5.

FINDING YOUR POSITION

To find a satellite, we are going to have to know where your location is as well as that of the satellite. Armed with both of these bits of positional information, we can easily calculate



CALCULATE your coordinates by starting at a marked meridian [see text] and calculating distance from meridian to your spot on earth.

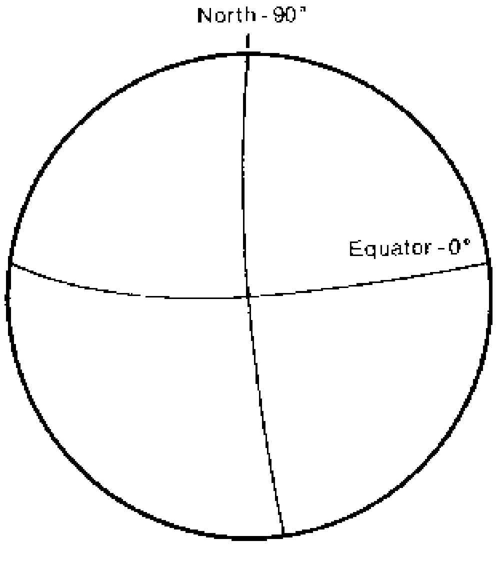


FIGURE 2

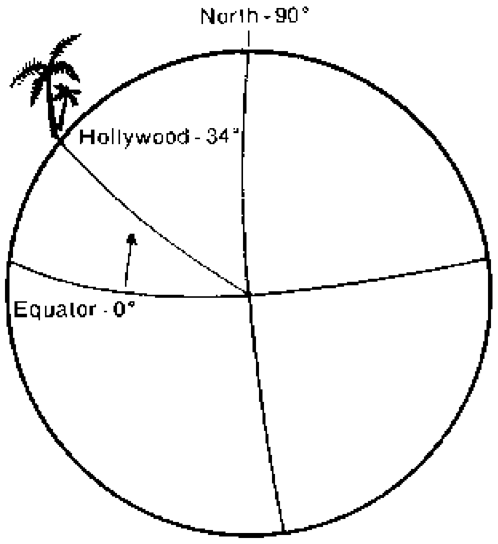


FIGURE 3

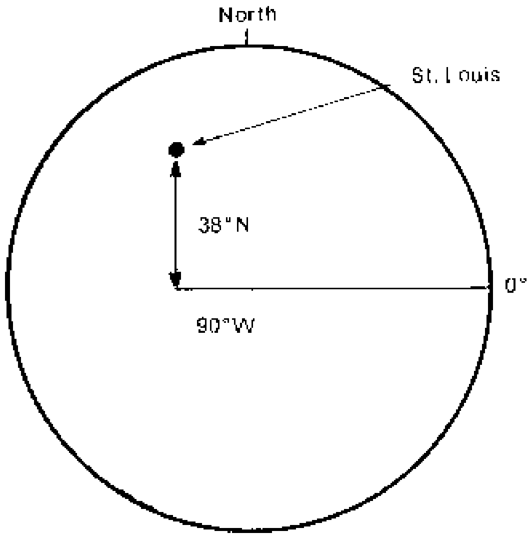


FIGURE 5

The angles we'd need to point the dish to receive it.

To find your coordinates, call your country surveyor or the local airport. Flight maps of your area will have marked meridian coordinates along the edge. All you have to do is measure with a ruler and interpolate to obtain accuracy to the nearest minute. Your local library reference desk would also have that information.

If a TV or radio tower is nearby, you can call the station and ask for their tower coordinates in as much as they must be on file with the FCC. The coordinates are for the tower itself and not necessarily the studio. Another method, if you happen to be in the United States, is to find a copy of Longitudes and Latitudes in the US published by the American Federation of Astrologers, #6 Library Ct., SE, Washington, D.C. 20003.

Probably your best bet is to buy a quadrangle map from a stationary or map store if you have one in your city. The government sells them too. Buy your maps at the **local** office of the Department of the Interior. They are much cheaper there.

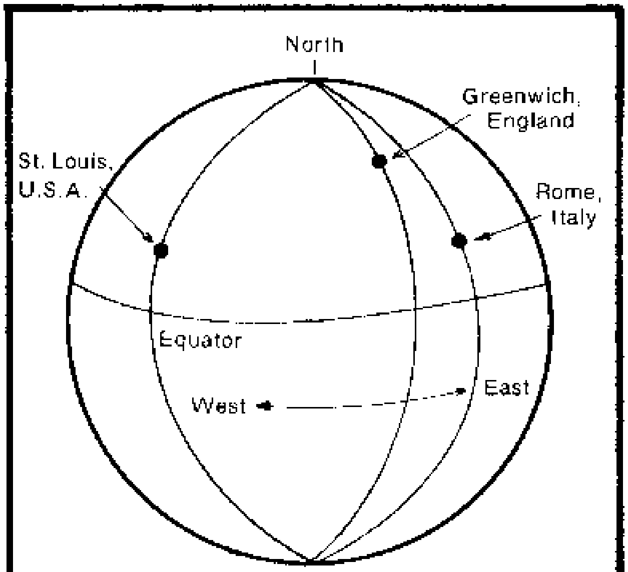


FIGURE 4

Use a ruler as a guide and measure from the edge to your location on both the vertical and horizontal plane. Then use simple proportion to convert the scale in degrees on your map to scale on your ruler and add the values to get your true location.

A typical quadrangle map covers 7 minutes 30 seconds (you might find a 15 minute map for sparsely populated areas). A typical length or width for these maps might be (in small units) 315mm. If you simply measure from the right edge to your point and find for example that the distance is 105mm, then you can plug into this formula and know the distance in seconds with very good accuracy:

length of map in degrees = 7 min 30 sec or (450 sec)
length of side in mm = 315mm
distance measured to point = 105mm

so...315mm : 450 sec :: 105mm : X sec

$$\frac{450 \times 105}{315} = 150 \text{ sec} = 2 \text{ min } 30 \text{ sec}$$

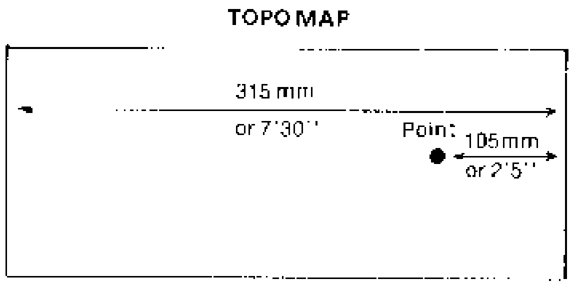
We then ADD this amount to the longitude along the right edge of the map. Likewise, we perform the same calculation for latitude making sure to measure from the side of the map with the lower value. If you must make a measurement from the higher value side, be sure to **subtract** the number you get from the higher value.

SATELLITE COORDINATES

Geosynchronous satellites have coordinate locations too. They are easy to find because as you well may know they appear to stand still at a single spot in the sky. Without resorting to celestial coordinate systems, we can say that all geosynchronous satellites have a latitude of zero because they are located directly above the equator seen in **figure 7**. Remember the equator is zero degrees latitude.

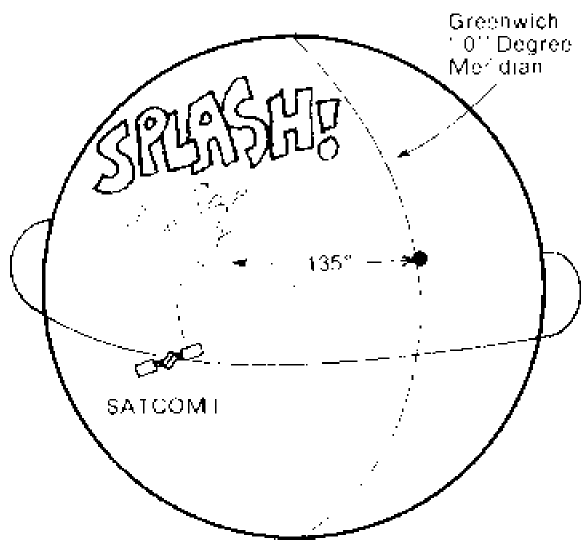
Let's make-believe that a satellite were to drop straight down out of the sky. It would land somewhere along the equator. We could still locate what was left of it if we knew the longitude of the satellite (it's angle east or west of Greenwich, England). Satcom I would plop into the Pacific Ocean on the equator at a point 135 degrees west of Greenwich.

Crashing Satcom I into the Pacific would cause us to lose a lot of nifty programming. So we'd better leave it up there and



Note: West longtitude is measured from right side of map. Measure from left side if located at eastern longtitudes.

FIGURE 6



RCA stock would also take a nose dive. FIGURE 8

Think only of the place where it **might** drop as a location we call a **sub-point** (the spot right underneath the satellite). The latitude of Satcom I's sub point is still zero degrees and the longitude is still 135 degrees west. By the way, the longitude of 53 more satellites is in the rear of this manual.

Knowing our location and the location of a satellite's sub point is about the only data needed to calculate antenna bearings. Still, we need some kind of graduated method to point the dish. As with coordinates, we use degrees of elevation and azimuth as dish pointing angles. Elevation is measured from the horizon at zero degrees up to a point directly over your head called the Zenith at 90 degrees seen in **figure 8**.

We simply tilt the dish up to the elevation of each satellite. As we've said before, the elevation is dependent on your position relative to the satellite. If we just happen to be located at the satellite's sub point, then the elevation of our dish will be 90 degrees, directly overhead. Most of the satellites we receive in North America however will be at practical elevations ranging from 10 to 55 degrees.

The azimuth angle is like a circle and is the horizontal direction we must point the dish to receive each satellite as seen in **figure 9**. Using north as zero degrees, we turn clockwise past east at 90 degrees to south at 180 degrees and around to west at 270 degrees and back to north.

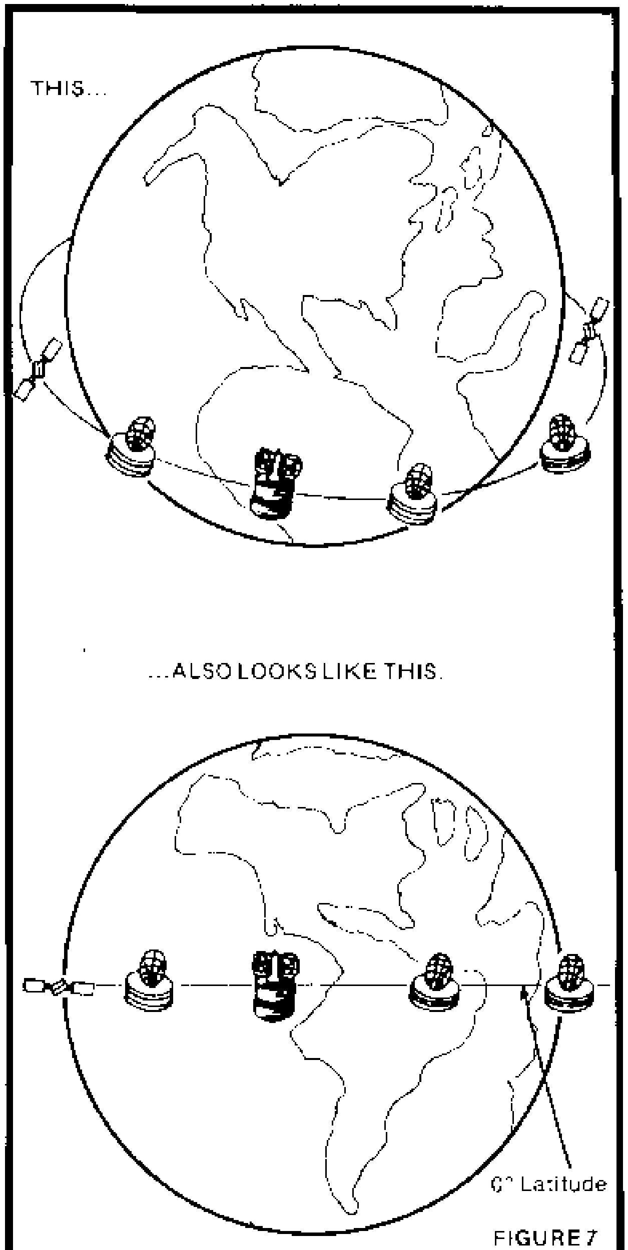

THIS...
...ALSO LOOKS LIKE THIS.
0° Latitude

FIGURE 7

Most of the satellites you receive in North America will be at azimuth angles ranging from 100 to 250 degrees. That corresponds to a point slightly south of east and on around to a point south of west. We've got more than 100 degrees here to play with and our accuracy at pointing might suffer more than with the elevation angle measurements where the force of gravity keeps our cut-out **STT inclinometer** pointer true. To get a better handle on references, we should try to get more than one. North and South are handy and we will try later to accurately determine both their positions. Knowing reference points and how to use them can make us pretty dangerous in the dish pointing department.

In North America, you can receive most of the satellites on your side of the earth if you have a clear view of the southern sky. There is a little 'gotcha' built into that phrase 'most of the satellites'. Besides the obvious problems of trees, buildings and terrestrial interference, you have the problem of the natural curvature of the earth putting a finite limit on the number of satellites you can see. It works out to 81 angular

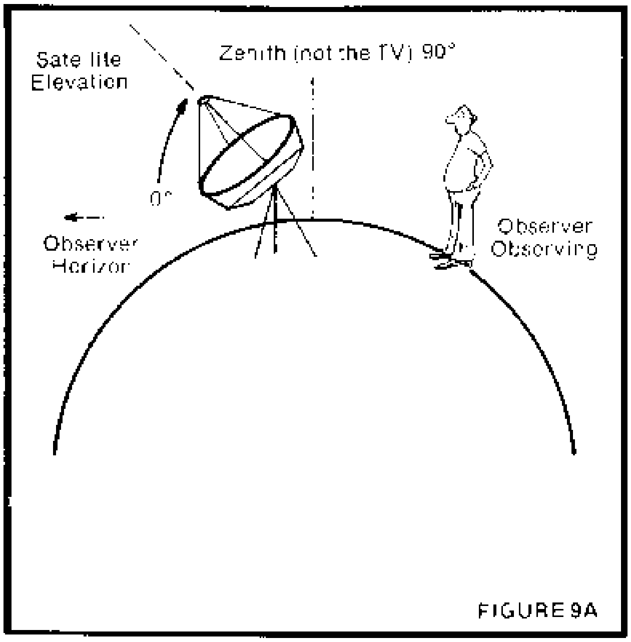


FIGURE 9A

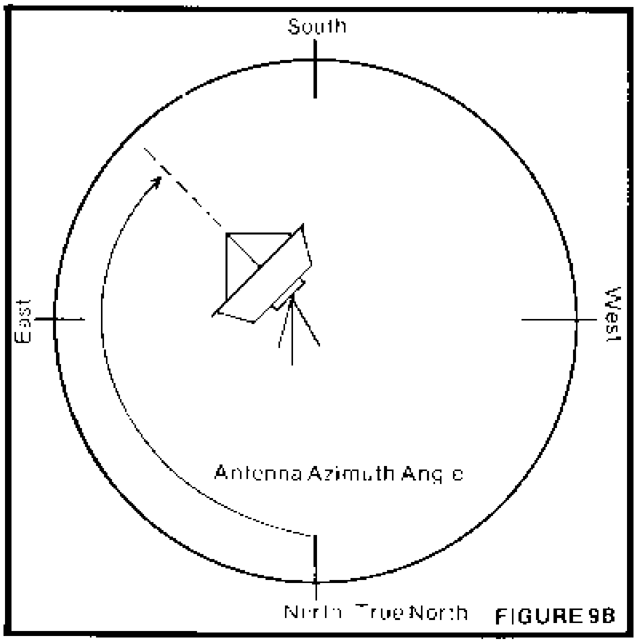


FIGURE 9B

degrees or so between you and the satellite sub-point as being the limit of your reach as seen in **figure ten**. Anything beyond is below your horizon. It follows then if your **latitude** is greater than 81 degrees, you've got a problem seeing any satellites at all!

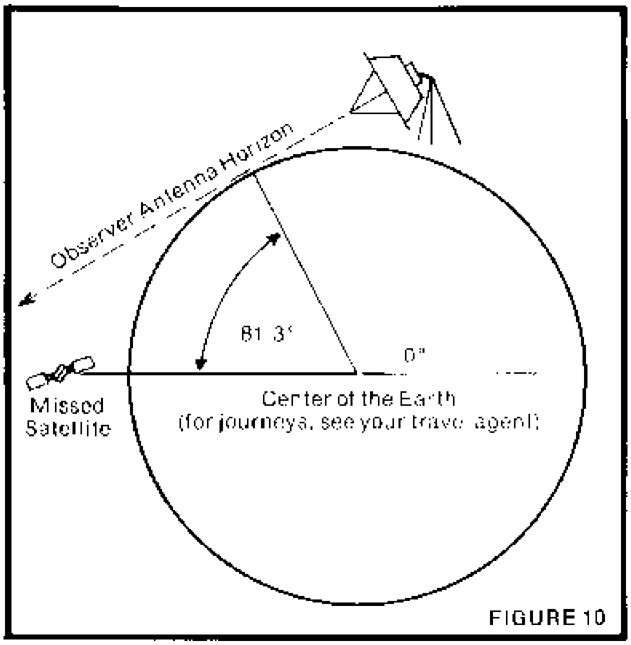


FIGURE 10

PLUG-IN FORMULAS CAN DO THE WORK

From the foregoing we see that you must make 2 adjustments to your antenna to receive a satellite that's visible from your location. The so called 'vertical tilt' and the 'horizontal twist' are about all that's necessary and is wholly dependent on your location coordinates and those of the satellite. Calculating antenna pointing angles for your location is not too difficult if you own a calculator.

No matter how cheap your calculator is, if it can do trig functions (sin, cos and the like), then you can use it to get exact dish pointing info. And you could even get around that if you happen to have a book of trig tables!

A number of very good articles have been written on calculating satellite bearings. An excellent article on the exact details appeared in the May 1978 issue of **Ham Radio** magazine by satellite pioneer H. Paul Shuch. You can probably read a copy at a local library or send $1.00 and a SASE to Microcomm, 14908 Sandy Lane, San Jose, California for a reprint of the article.

PROGRAMMABLE CALCULATOR makes satellite bearing calculations a snap. But you will find it even easier to send your coordinates to the STT COMPUTER for a customized chart for your location [see page 46].

Ham Radio March 1980 also had an article along with an HP-29C calculator program. And Bill Johnston wrote in QST magazine for March 1978 a simple method to calculate bearings which we have converted to a useful computer program with a satellite location data base.

LET CALCULATIN' ENGINES DO THE WORK!

Written for the popular TRS-80 computer, this program will run on nearly any micro supported by a stiff **basic**. Lines 10 - 200 do a graphic thingy on the TRS 80 screen. Pay particular attention to the needed down arrows on the tops of lines 120,

```
10 '******************************************************
20 '
30 '                        GEOSYNC LOCATOR PGM
40 '
50 '******************************************************
60 CLS:PRINT@192,"  GEO-SYNC SATELLITE TV";
70 PRINT@256,"         LOCATOR!!";
80 FORX=1TO61:PRINT@X,"-0-";:GOSUB120:NEXT
90 PRINT@852,"ANTENNA BEARINGS FOR 54 GEO-SYNC SATELLITES!";
100 PRINT@990,"(C) 1979 STEPHEN GIBSON ";
110 FORX=1TO1500:NEXT:GOTO220
120 IFX=1THENPRINT@704,"
*         *
  *  +  *
     -";:RETURN
130 IFX=10THENPRINT@704,"
 *
 *
   +
     *  *";:RETURN
140 IFX=30THENPRINT@704,"
    *
   *
     +
       *  *";:RETURN
150 IFX=35THENPRINT@842,".";:RETURN
160 IFX=45THENPRINT@722,".";:RETURN
170 IFX=55THENPRINT@602,".";:RETURN
180 IFX=58THENPRINT@422,".";:RETURN
190 IFX=59THENPRINT@303,".";:RETURN
200 IFX=61THENPRINT@183,".";:RETURN
210 RETURN
220 M1=PEEK(16422):M2=PEEK(16423)
230 CLS:PRINT@320,"GEO-SYNC SATELLITE PROGRAM"
240 PRINT:'(C) 1979 STEPHEN GIBSON
250 POKE16553,255:RESTORE:'TRS-80 ROM FIX
260 PRINT"DO YOU WANT ;":PRINT:PRINT"1 = LIST OF SATELLITES"
270 PRINT"2 = CALCULATIONS"
280 PRINT:PRINT:INPUT"WHICH ";A:IF A=1 THEN 1010
290 '
300 CLS:PRINT"EARTH STATION COORDINATES:":PRINT
310 PRINT"LONGITUDE - INPUT DEGREES,MINUTES,SECONDS"
320 INPUT VD,VM,VS
330 INPUT"IS THAT EAST OR WEST LONGITUDE (E/W) ";V$
340 PRINT:PRINT"LATITUDE - INPUT DEGREES,MINUTES,SECONDS"
350 INPUT HD,HM,HS
360 INPUT"IS THAT NORTH OR SOUTH LATITUDE (N/S) ";H$
370 '
380 CLS:PRINT@384,"":PRINT"DO YOU WANT....":PRINTTAB(18)"1 = PRINTER OUTPUT"
390 PRINTTAB(18)"2 = SCREEN OUTPUT";:INPUT"          WHICH  ";U:IFU=1 THEN 420
400 POKE16422,88:POKE16423,4:CLS:GOTO430
410 '
420 CLS:INPUT"READY PRINTER...THEN PRESS 'ENTER'";A$
430 LPRINT CHR$(14) " GEOSTATIONARY SATELLITE ANTENNA BEARINGS"
440 LPRINT" ":LPRINT"                    (C) 1979 STEPHEN GIBSON"
450 LPRINT" ":LPRINT"EARTH STATION AT : ";VD;" : ";VM;" : ";VS;" ";
460 LPRINTV$;"     ";HD;" : ";HM;" : ";HS;" ";H$
470 LPRINT " "
480 IFU=1THENLPRINT"SATELLITE","NODE"," AZIMUTH"," ELEVATION","DISTANCE(MI)"
490 LPRINT " "
500 '
510 IF U=1 THEN 540 ELSE LPRINT"SATELLITE";TAB(20);"NODE";
520 LPRINTTAB(31);"AZIMUTH";TAB(40);"ELEVATION";TAB(50);"DISTANCE(MI)"
530 '
```

```
540 S$="W":' WEST LONG FOR ALL SATELLITES!!
550 G = VD+(VM+VS/60)/60 : A = HD+(HM+HS/60)/60
560 IF V$="W"THEN G=-G
570 IF H$="S"THEN A=-A
580 '
590 'CALCULATIONS
600 FOR J=1TO54 : READ SA$ , F :F = -F
610 B = G - (F)
620 IF B>180 THEN B = B-360
630 IFB<-180THENB=B+360
640 IFB=>81.3THEN D=B-81.3: GOTO 910 :' ERROR!!
650 Q=(COS(B*.0174533))*(COS(A*.0174533))
660 C=(-ATN(Q/SQR(-Q*Q+1))+1.5708)*57.29578
670 IFC=>81.3THEND=C-81.3: GOTO 910 :' ERROR!!
680 '
690 ' DO PRINT-OUT
700 IF U=2 THEN 720 :'SCREEN BRANCH
710 CLS:PRINT@384,CHR$(23) SA$,ABS(F)
720 C1=C*69.057:'MILES TOO SUBPOINT (NOT USED)
730 AA=180+(ATN(TAN(B*.0174533)/SIN(A*.0174533)))*57.29578
740 IFA<=0THENAA=AA+180
750 R=3957:H=22245
760 S=SQR((R↑2)+((R+H)↑2)-2*R*(R+H)*COS(C*.0174533))
770 EE=(((S↑2)+(R↑2)-((R+H)↑2)))/(2*R*S)
780 E=(-ATN(EE/SQR(-EE*EE+1))+1.5708)*57.29578-90
790 '
800 IF U=2 THEN LPRINT SA$;TAB(20);ABS(F);TAB(30);AA;TAB(40);E;TAB(50);S:GOTO 830
810 IF U=1 THEN LPRINT SA$ , ABS(F) , AA , E , S
820 '
830 NEXT
840 '
850 FORX1=1TO1000:NEXT
860 POKE16422,M1:POKE16423,M2:'RESTORE LPRINT
870 PRINT@960,:INPUT"WANT ANOTHER Y/N ";A$: IF A$="Y" THEN 230
880 '
890 CLS:END
900 '
910 ' ERROR FLAG
920 IF U=1 THEN 940 ELSE LPRINT SA$;TAB(20);"BELOW YOUR HORIZON BY ";D;" DEGREES"
930 FOR X = 1 TO 100 : NEXT : GOTO 830
940 CLS
950 PRINT@384,CHR$(23) SA$, ABS(F) :LPRINT SA$,ABS(F),
960 LPRINT" BELOW YOUR HORIZON BY ";D;" DEGREES"
970 GOTO 830
980 '
990 ' LISTING
1000 '
1010 C=0:CLS:PRINT:PRINT"SATELLITE      W-LONGITUDE":PRINT
1020 C=C+1:READ A$,A
1030 IF A$="" THEN PRINT :INPUT "PRESS ENTER TO CONTINUE";E$: GOTO 230
1040 PRINTA$,A
1050 IF C <> 10 THEN 1020 ELSE PRINT :INPUT"PRESS ENTER TO CONTINUE";E$:GOTO 1010
1060 DATA "ATS-3",69,"GOES-1",75
1070 DATA "COMSTAR 3",87,"WESTAR 3",91,"COMSTAR 2",95,"WESTAR 1",99
1080 DATA "ANIK A1",104,"SMS-1",105,"ANIK A2",106.5,"ANIK B",109,"ANIK A3",114
1090 DATA "-CTS-",116,"SATCOM 2",119,"WESTAR 2",123.5,"COMSTAR 1",128
1100 DATA "SATCOM 3?",132,"SATCOM 1",135,"SMS-2",135
1110 DATA "ATS-6",140,"ATS-1",149,"STATSIONAR 10",170
1120 DATA "INTELSAT IV F4",181,"MARISAT 2",183,"INTELSAT IV F8",186
1130 DATA "STATSIONAR 7",220,"-CS-",225,"-ETS-",230,"-BSE-",250
1140 DATA "STATSIONAR T",261,"EKRAN 2",261,"EKRAN 1",261,"STATSIONAR 6",275
1150 DATA "PALAPA 1",277,"STATSIONAR 1",280,"PALAPA 2",283,"MARISAT 3",287
1160 DATA "INTELSAT IVA F3",297,"INTELSAT IV F1",298.6,"INTELSAT IV F6",300
1170 DATA "INTELSAT IV F5",300,"STATSIONAR 5",302,"SYMPHONIE 1",311
```

```
1180 DATA "STATSIONAR 9",315
1190 DATA "INTELSAT IV F7",1,"INTELSAT IV F2",4,"SYMPHONIE 2",11.5
1200 DATA "STATSIONAR 4",14,"SIRIC",15,"MARISAT 1",15,"INTELSAT IVA F4",19.5
1210 DATA "INTELSAT IVA F1",24.5,"STATSIONAR 8",25,"INTELSAT IVA F2",29.5
1220 DATA "INTELSAT IV F3",34.5
1230 DATA "",0
1240 END
```

130 and 140.

In line 220, the program peeks the line printer device control block so we can have the option of sending the output data to the printer or the screen by simply poking the address of the screen driver routine into the printer control block. This might explain why nearly all data print-outs are LPRINTS. You chose the option down in line 390

Meanwhile back in line 280 you are given the option of displaying the 54 satellite data base or running calculations based on longitude and latitude coordinates you input in lines 300 and 360. Based on your choice of CRT or line printer output, the program enters a loop in line 600 to do the actual calculations

After being converted to decimal values, the program seeks to determine the azimuth, elevation and distance to the satellite from your coordinates. It first solves for the great circle angle in lines 610 to 670. If the angular distance to the satellite sub-point is greater than 81.3 degrees, the program branches to an error message in lines 910 to 930 with the not too important data of how far off you are.

Next the azimuth is calculated in line 730, the slant range distance to the satellite in line 760, and the elevation in line 780. The info is printed in format in lines 800 and 810.

IF IT WORKS...MODIFY IT!

One of the Edsel Murphy's corrollaries is that a program that runs correctly is obsolete. To serve that ever present need to modify, I can suggest you fiddle with the printer formatting. You may need to anyway depending on your line printer. You can add satellites to the data base by inserting data statements. The only gotcha to lookout for is to be sure the last data statement is the one we have in line 1230, a string null and a zero. By the way, the data format is a string enclosed in quotes followed by the longitude of the bird. You must also change the range of the **for/next** loop in line 600.

If you are curious how many miles you are from the sub-point, print out the value of C1 in line 720. The current screen formatting won't support it. So you'll need to fool with lines 800 or 810. Also nearby are the constants used to calculate the angles. In line 750 is the radius of the earth as R and the distance to the belt from the equator in H. Both values are in miles.

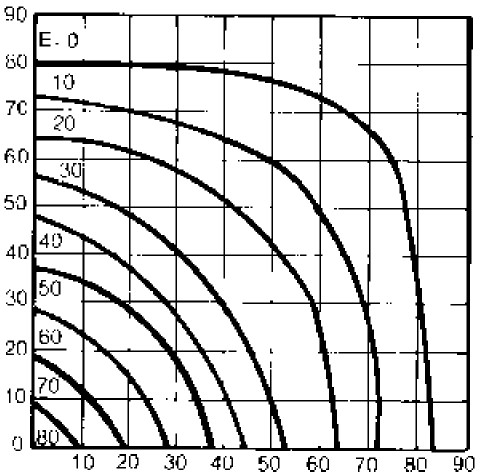
FOR THOSE WHO CAN'T WAIT!

You can skip the calculating completely by using the **STT Antenna Pointing Charts** or better yet, send in an order for a customized computer created antenna pointing chart for your location (see page 46 of this manual) that will give you the exact azimuth and elevation headings plus other essential information based upon your exact location.

The STT Pointing Charts are a cheap and dirty way to save time. While general angles from a chart are not the most accurate method, they do make it easy for you to point your antenna within a few degrees. For many, this may be the best accuracy possible even with computer derived pointing info. All kinds of errors can creep in when you attempt to translate numbers to physical positions. The **STT Pointing Charts** may not improve your translation accuracy, but they still surely save you time at getting your antenna 'in the ballpark'. Later, we can work on more accurate methods.

Two charts are used. One for reading elevation, and the other for azimuth. Both work about the same. You enter the chart at the bottom with what you have figured as the difference in Longitude between you and the satellite. In the example given, Satcom I is at 135 degrees. Our longitude here in Hollywood is 118 degrees and so the difference is 17 degrees.

ELEVATION LOOK ANGLE CHART **FIGURE 11**
E = Elevation Angle



Difference between your longitude
and satellite subpoint.
Eample for Hollywood at 118°W.
Satcom I 135° Minus Hollywood 118° = 17° Difference.

Back now to the chart, we move **up** from the bottom to the point that corresponds to our latitude as seen at the left. If you land on a line, you're okay. Reading one of the curved lines on the graph should be easy. If you don't land on a line, you'll have to do some interpolation. You can't get more than about 5 degrees off anyway, so it should be a piece of cake. In our example, we entered at 17 degrees and moved up to the latitude of Hollywood which is about 34 degrees. There we see that interpolation will be necessary and a 'guesstimate' on the dish elevation angle is about 45 degrees. Actually, the computer says it's 47 degrees! That's not too far off that we can't rock the dish till we hit it on the money.

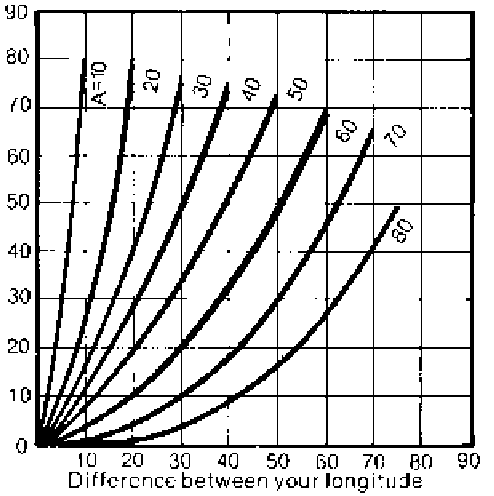
The azimuth measurement is the same except for a little gotcha we built in to keep you on your toes. You enter the chart from the bottom as before and move to your latitude. There you read a wierd number. In our example, a move up from 17 degrees to the Hollywood latitude at 34 degrees gets us an interpolated value from the lines as 31 degrees. What do you do with that? **Add** it to 180 degrees and point your dish. That means 180 + 31 = 211 degrees. Actually it should be 208. An error of 3 degrees is still not too hard to live with Where's the catch?

You most certainly will have satellites whose azimuth angle from your location will be less than 180 degrees. What then? You will have to **subtract** the number from 180 degrees. How will you know when to subtract? The secret is the difference in the longitudes. A **negative** result means you subtract, while a **positive** result means you add.

If Comstar sits at 87 degrees, a difference of 31 degrees exists for Hollywood (87 - 118 = -31), so we enter the chart at

AZIMUTH LOOK ANGLE CHART **FIGURE 12**

A = Azimuth Angle



Example for Hollywood at 118°W.

SATCOM I 135° Minus Hollywood 118° = 17° difference.

the bottom and move up to 34 degrees (Hollywood latitude) and read about 47 degrees. Subtracting from 180 (because the difference was negative), we get 133 degrees as the azimuth angle. The actual value is 132.

The charts have their good and bad points. Accuracy within 5 degrees is okay as long as you know you will have to do some fiddling. It's also a good method to check your calculations. And they are fast. By far, your best bet is to send us the data in the back of the manual along with your coordinates and we will send you a computer derived pointing chart for your location.

HOW TO BUILD A SIMPLE ANTENNA MOUNT

It's hard to say when the initial excitement of seeing your first TV pictures from space will wear off. Perhaps never. It might depend a lot on how much of the work you do by yourself. It's darned hard to measure satisfaction. It is also possible that how much work you do just to maintain a watchable picture will affect your interest. Trying to keep the dish from being blown off the bird by the wind is a mean feat unless you have a firm anchor tied at several points.

Suppose you have a saw horse or a child's swing set to use as a quickie mount. Your dish is just leaning there waiting for the first breeze or someone to bump it that critical inch or two off the satellite. What can you do right **now** to stop the annoyance? A fast trip to the hardware store is a surefire road to solutions. If you are using a 'swing set' mount seen in **figure 13**, you can buy some long TV antenna U bolts and some extra 5 foot sections of antenna mast. Bolt the mast sections anywhere along the 'A frame' part and run them out to your dish, bolting them at any convenient point. Use an electric drill on the dish. The goal is to secure the dish from **at least 3** points. Where it leans against the swing set might be counted as one.

If your antenna leans against a saw horse or a tree or even the house, you can sink several sections of cold water pipe into the ground next to the dish as seen in **figure 14**. Using the long U bolts as above, you can run pipe or TV mast sections to the dish where more U bolts secure them. Sinking the pipe is easy if you use a garden hose and a pipe fitting to let water power do all the work.

The key idea in both these quickie solution examples is **rigidity**. Not only will you have an antenna that will stay put during the mild storm, but you are less likely to accidentally knock it off the bird while making other adjustments.

As more and more programming gets up on satellite, you may begin to wonder how to make your fixed mount adjustable so that you can see what's on the other birds. The 'swing set' method can be made adjustable by changing the length of the pieces of connecting mast you installed as you tilt the dish. The saw horse setup might go on a large turntable made from automobile parts. Either method is good for about as long as you want to spend to see if it works. Otherwise you might just as well go for the throat and build a **real** antenna mount!

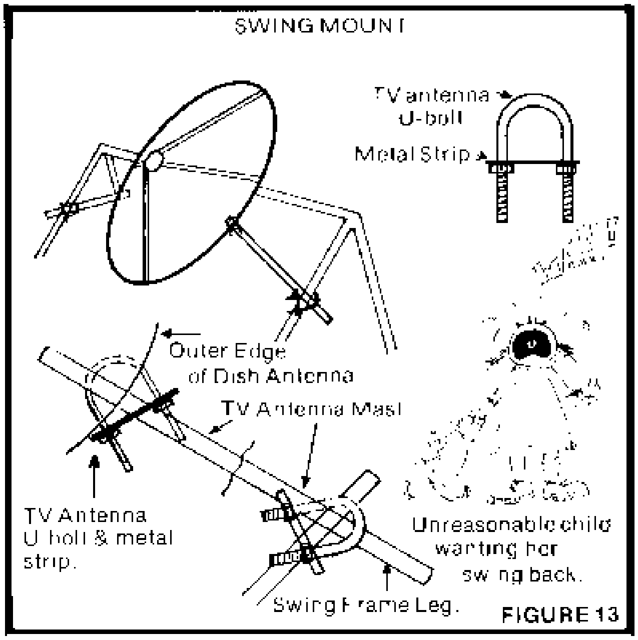

SWING MOUNT
TV antenna U-bolt
Metal Strip
Outer Edge of Dish Antenna
TV Antenna Mast
TV Antenna U bolt & metal strip.
Unreasonable child wanting her swing back.
Swing Frame Leg.

FIGURE 13

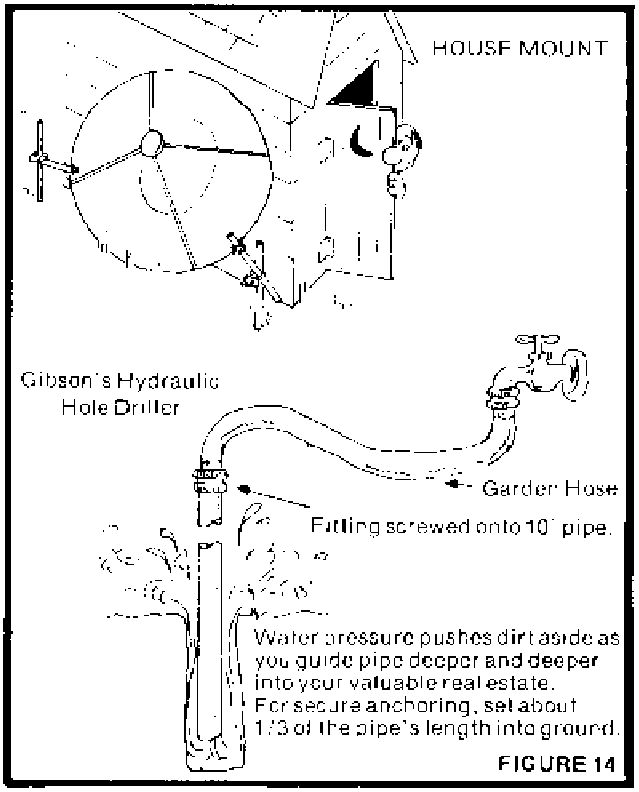

HOUSE MOUNT
Gibson's Hydraulic Hole Driller
Garden Hose
Fitting screwed onto 10' pipe.
Water pressure pushes dirt aside as you guide pipe deeper and deeper into your valuable real estate.
For secure anchoring, set about 1/3 of the pipe's length into ground.

FIGURE 14

BACK TO THE HARDWARE STORE

Other than a fixed mount you could build from parts bought at a junk yard, you have two choices for a moveable mount. They are the AZ/EL and the polar mount.

GIBSON'S "LAUNDRY POLE" MOUNT

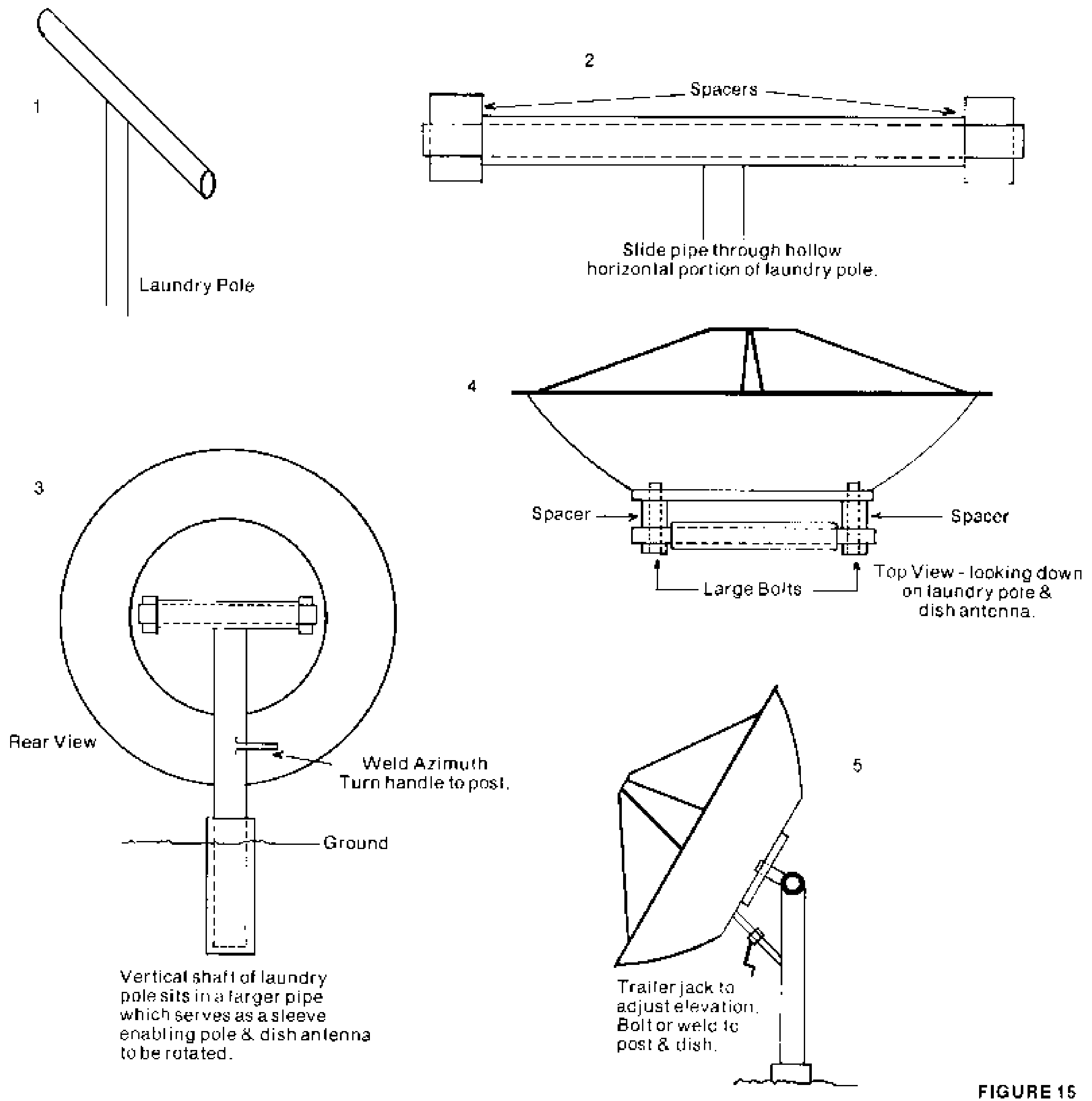

1
Laundry Pole
2
Spacers
Slide pipe through hollow horizontal portion of laundry pole.
4
Spacer
Spacer
Large Bolts
Top View - looking down on laundry pole & dish antenna.
3
Rear View
Weld Azimuth Turn handle to post.
Ground
Vertical shaft of laundry pole sits in a larger pipe which serves as a sleeve enabling pole & dish antenna to be rotated.
5
Trailer jack to adjust elevation. Bolt or weld to post & dish.

FIGURE 15

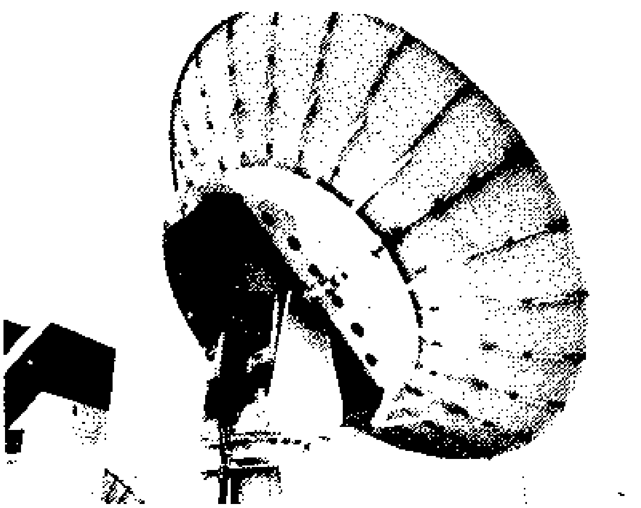
The AZ/EL or azimuth/elevation mount is by far the most popular because you can aim at just about any point in the sky. Not only can you aim the antenna at any visible geostationary satellite, but you can try your hand at some of the polar orbit birds such as the Russian Molniya. Pictured here is the essence of the AZ/EL mount.

Two axis are used to aim the antenna. The elevation axis handles the up and down while the azimuth axis is used for the left and right movement. The elevation adjustment is measured from the horizon at zero degrees up to a point directly over your head called the zenith at 90 degrees. Use the cut-out **STT Inclinometer** as a guide. The azimuth adjustment can be in any direction on a horizonal axis or circle from a zero degrees point facing North in a clockwise direction around past south at 180 degrees and back to north at 360 degrees.

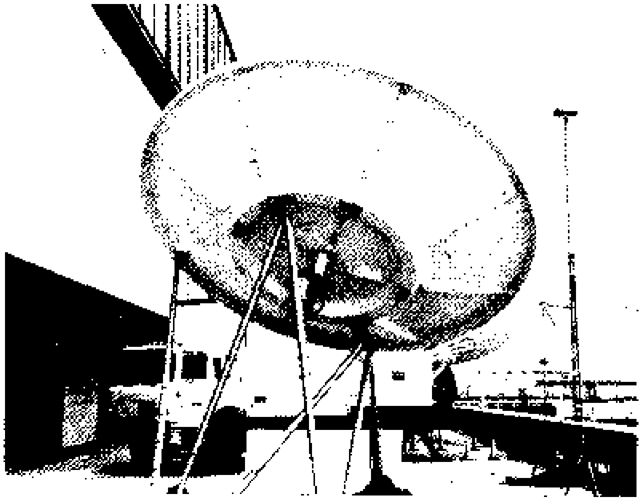
As we learned from the discussion on dish pointing, all we really need is an elevation and azimuth angle for a satellite from our location and we can find it with ease. We simply set the antenna elevation to the calculated elevation with the inclinometer and then swing the antenna around on the horizontal azimuth axis to the calculated azimuth angle. A quick fine tuning or rocking of the antenna back and forth or up and down should find us a satellite. More on fine tuning techniques later.

POLAR MOUNTS

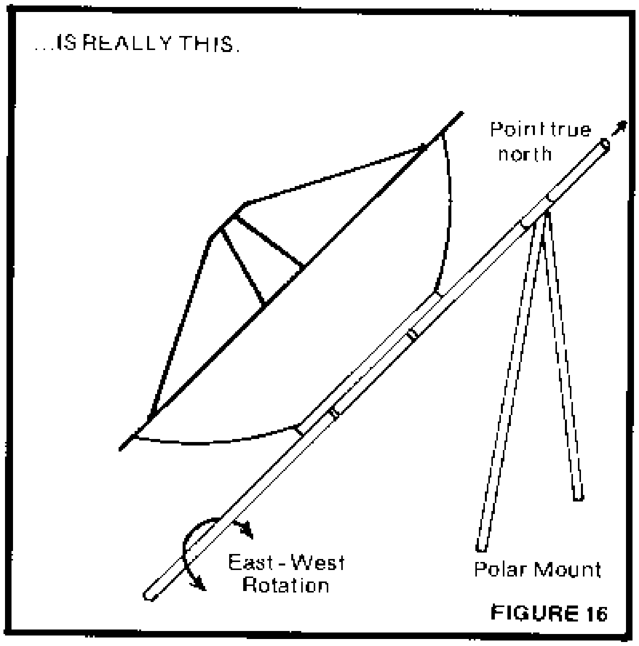
If you've ever gazed through a telescope equipped with a clock drive, you know that the scope appears to be "locked-on" to the celestial object you are viewing. This is especially true if it has been properly aligned to a point near the pole star. Hours



WHILE IT LOOKS complicated you can build a jiffy-version of this mount using a backyard laundry pole!



SIMPLE POLAR MOUNT. Note the adjustable pole at left which is used to position the dish. NOTE: This...



...IS REALLY THIS.

FIGURE 16

can go by and the object stays in the field of view of the scope. The way it all works is very simple. The turning axis of the earth can be seen by those of us in the northern hemisphere as a point very near **(within a degree)** the North Star Polaris. If your telescope axis were also on **this axis**, then a motor adjusted to the speed of rotation (once every 24 hours) would have the scope appear to be locked on to any star or object it was pointed at. A satellite antenna polar mount, as it's called, is very similar. The single turning axis is aligned north and south and the antenna can be rotated in a sort of East-West direction.

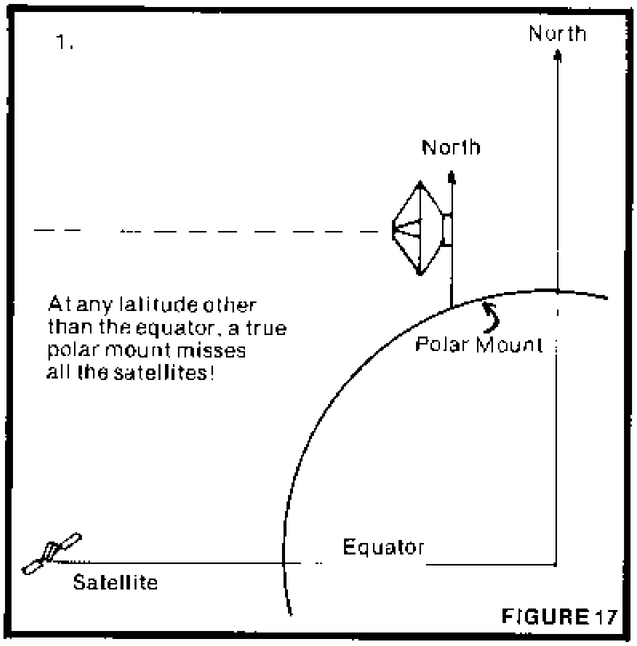
The effectiveness of a polar mount is it requires only one moveable axis and is easier to handle. Think of the simplicity of merely moving one axis so the antenna sweeps across the entire belt of satellites visible from your location.

The plain truth of the matter is that such a practical idea can be very impractical unless you live on the equator. It is **there** that the elevation angle is 90 degrees and the satellites are in a belt or arc directly overhead. The polar mount antenna can sweep the satellite belt with ease so long as the mount or turning axis is aimed in a **true** north-south direction. Any misalignment will cause error. It's really no big deal if you do a careful installation job.

But suppose you live in St. Louis where your latitude is 38 degrees and you are no longer directly beneath the arc or belt of satellites? **If** you **align** the polar mount to **true** north, your antenna will be looking out into space and missing all the satellites, as seen in **figure 17**.

So to receive them you must make an elevation adjustment to tilt the dish **down** enough to see the belt of satellites seen in **figure 18**. You sometimes hear this adjustment referred to as a **declination** adjustment because the up and down motion on a telescope polar mount is referred to as declination rather than elevation. This is because we are no longer referencing a line to the horizon, but a line reaching out into space that is 90 degrees to the turning axis of the antenna.

Because the axis of the antenna and the arc of the satellites are **not** the same, you can no longer swing across the **entire** belt that may be visible from our location and expect to be **'right on boresight'** for each satellite despite our careful declination adjustment. Instead you will hit only some of the



At any latitude other than the equator, a true polar mount misses all the satellites!

FIGURE 17

satellites 'right on' and some will be off by an amount wholly dependent on your latitude. The farther north or south you go from the equator will control the amount of error you will accumulate as seen in **figure 19**.

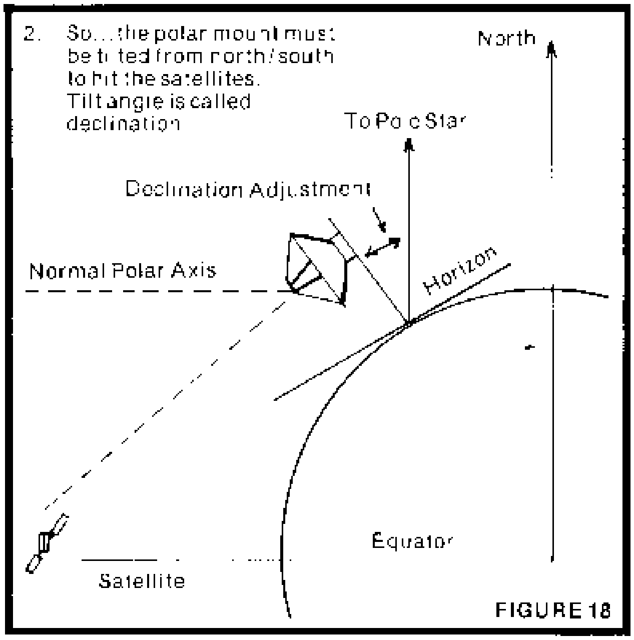

2. So...the polar mount must be tilted from north/south to hit the satellites. Tilt angle is called declination
North
To Pole Star
Declination Adjustment
Normal Polar Axis
Horizon
Equator
Satellite

FIGURE 18

So only some of the satellites you find using a polar mount will be right on boresight. While this may not necessarily be a problem for rather small aperture antennas, larger aperture dishes may have trouble getting the best picture because they will never be pointed directly at the satellite which should make a big dent in your reception especially in the sparklie department!

A neat trick you can try if you are intent on using a polar mount is to shift the axis of the mount **off** true north so that the arc of the antenna will swing through more satellites. This amounts to making a very slight azimuth adjustment in addition to the declination adjustment you made earlier.

Still another method is to throw in the towel and make your declination adjustment variable so that you can fine-tune your antenna up and down to compensate for the polar arc error. Perhaps you see now that the polar mount has limited advantages over the AZ/LL mount in as much as TVRO's with small aperture antennas function best when aimed right at the satellite.

On the other hand you may only want to receive a limited number of satellites and they may just happen to be close together or nearly on opposite ends of your visible belt of satellites. Then the polar mount will really shine because all you need to do is make the azimuth adjustment track so that the satellites you want will fall on the arc of your antenna.

BUILDING YOUR SUPER MOUNT

You can build your super mount any number of ways. Specific details here might not fit your antenna. Too many variables. You can attack the project two ways. Use a 'Bolt Together' method or the 'Weld it Solid' method. Both have their advantages.

The 'Bolt Together' method may look very attractive if you have ever owned an erector set. All you do is buy the basic

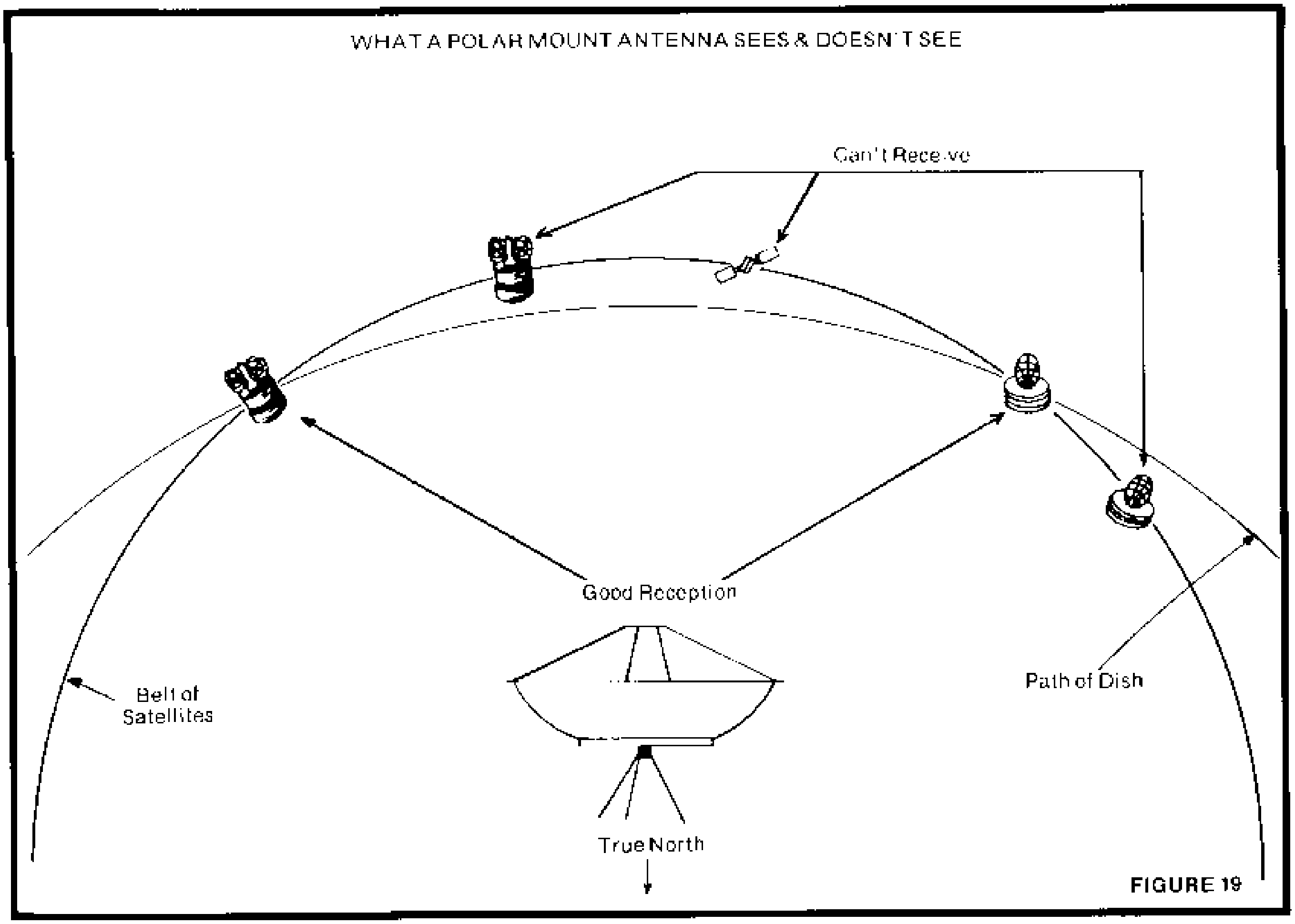

WHAT A POLAR MOUNT ANTENNA SEES & DOESN'T SEE

FIGURE 19

ADJUST AZIMUTH TO GET MORE SATELLITES.

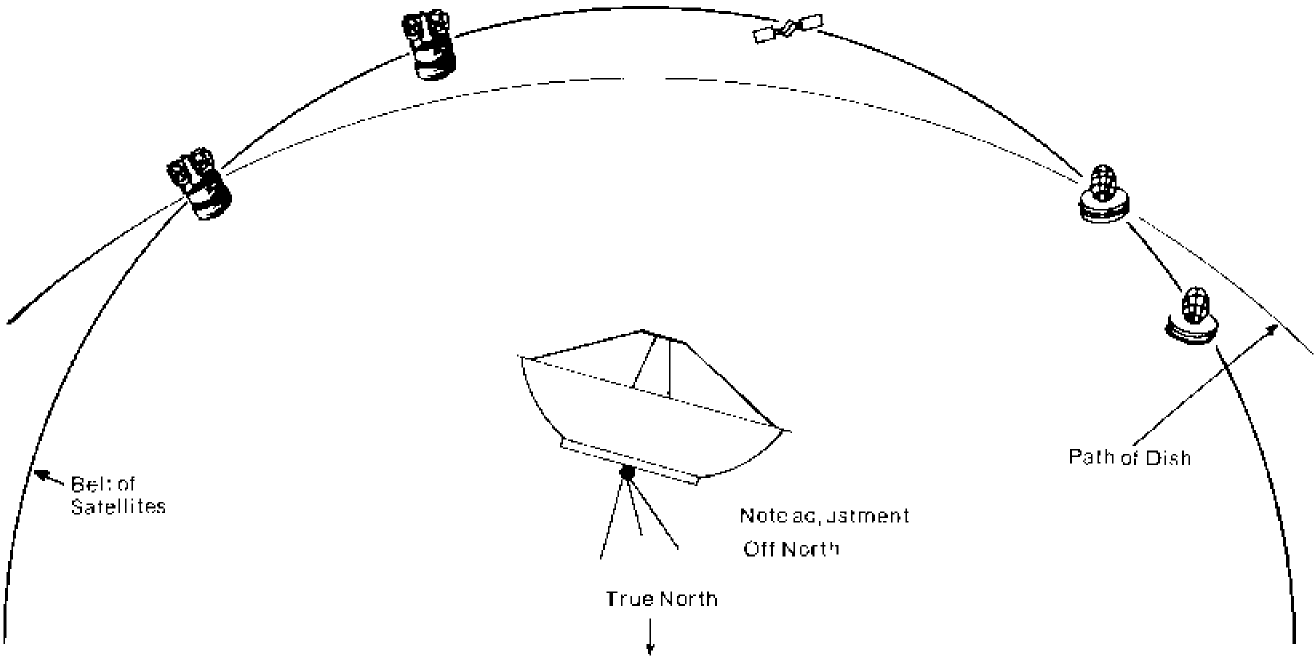
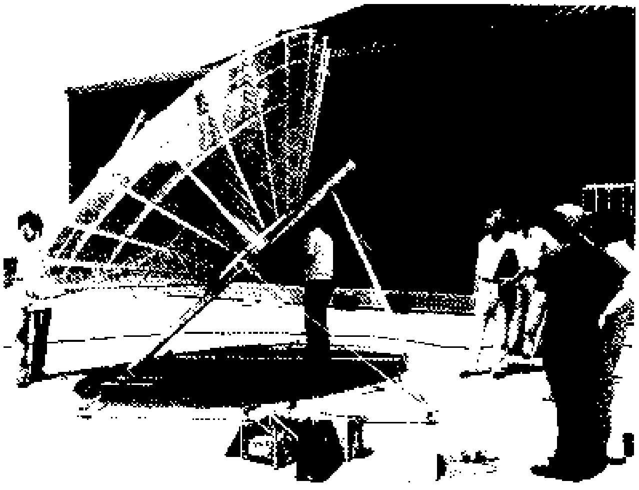


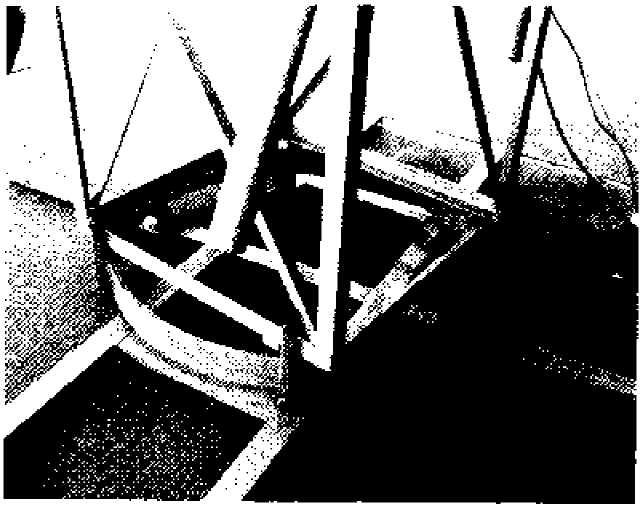
FIGURE 20

parts you need, do some cutting and then apply a generous dose of nuts and bolts. The only tools you might need to buy, rent or borrow are a metal saw (electric jig saws are cheap) and a 1/4 inch drill. You can buy bits that convert up to 3/8 inches and beyond. Large U bolts hold the whole assembly together. Lock washers are a **must** for this kind of construction.

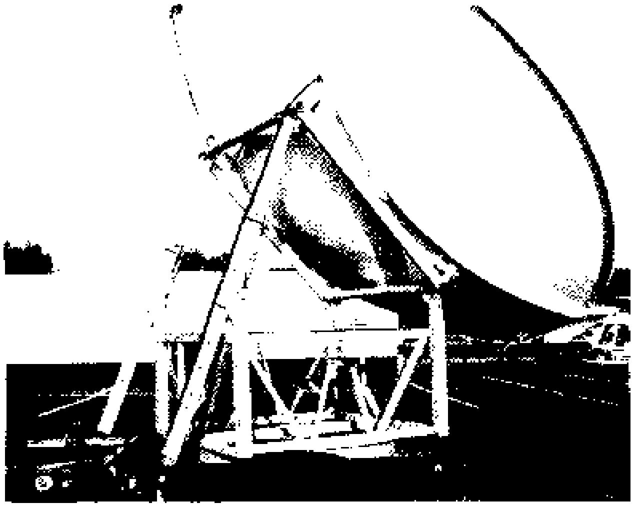
The only disadvantage you may discover is that a Bolt Together mount is not cheap. It's not the basic metal stock that will bother you so much as the price of the smaller hardware. Little things in plastic bags cost nearly twice what they would if



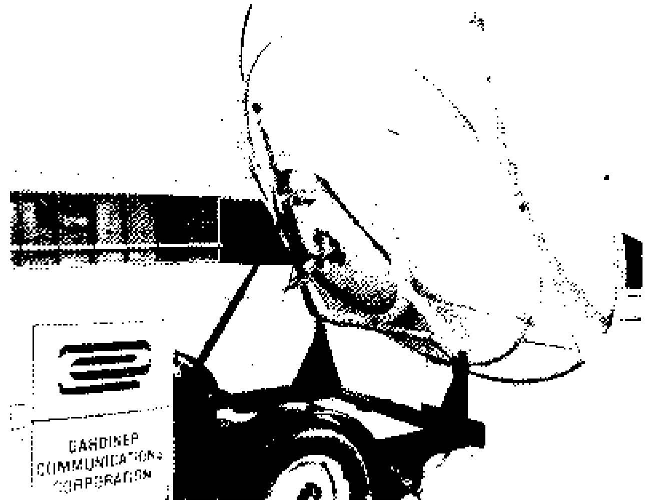
EXAMPLE of bolt-together mount construction [Kintech Technology dish at SPTS '79 in Oklahoma].



WELDED MOUNT construction example from Paraframe commercial 12 foot dish during SPTS '79 in Oklahoma.



ONE [commercial] approach to elevation control [sloping rod]. Azimuth is handled with center-pinned cage support that rotates on center.



SIMPLE but effective elevation control; antenna base is hinged and diagonal strut marries small end-mounted jack-screw and telescopic rod with 5 degree step adjustment holes.

you found a barrel of them! Your best bet is to shop for your hardware.

Despite the fear of torches, the 'Weld it Solid' method is cheaper and perhaps slightly better in the basic rigidity department. You can buy the most ugly hunks of metal at a junk yard and paint them later after you've cut them to the exact dimensions for your design. The possible advantages may escape you because the thought of seeing yourself close to all those hot sparks flying all over may frighten you. While you may think that welding is for welders, the simple truth is that it is almost as easy as soldering and almost all the sparks you see are cool long before they reach you.

What about the ones that do? Wear a long sleeve shirt (no holes) and some gloves and you should be pretty safe from harm. Of course you must also use a welding hood or some goggles. The main thing is to keep your body covered.

You can borrow or rent a welding outfit very cheaply. Your best bet for welding rod may be 6013 arc welding rod. 1/8 inch rod works very well for AC/DC welders. Running about 90 amps should get the job done. Run your gas pressure around 8 to 10 pounds and Oxy at about 40 pounds.

You can use an electric or a gas welder to build your mount. Either kind work very well though some veteran welders may suggest a preference. Just be sure to knock the 'scale' off when you weld on top of a weld.

Rental prices vary from city to city. Keep in mind that a 200 amp unit at Sears is under $150 new, so don't expect to pay much of a rental fee. Some places rent by the hour. You can save a few bucks if you pre-cut the metal. It's hardly worth it when a good cutting tip such as a Victor #0 or #00 will chop stuff for you at a pretty good speed.

The last part of the construction phase will be getting the dish up and onto the mount. While a block and tackle will work, you may have better luck at renting a chain or cable hoist. Look in the yellow pages for an equipment rental company.

ANTENNA POINTING TIPS

By now you are well aware of the info needed to quickly and accurately point your antenna. You have several sources here for the same satellite location data and details on how to obtain your location coordinates and even specific pointing aids to get you nearly on boresight without once looking at a TV screen. We've reached the bottom line where all that remains is to simply swing the dish around to the proper azimuth position and tilt it up to the calculated elevation angle and quit.

It should be easy to determine the antenna's elevation with the help of the cut-out **STT Inclinometer**. But finding azimuth is quite another matter. You can sight a line with a compass and point the dish along the line. If you buy a compass, be sure to find one with very clear degree markings. The larger the better. The important thing to remember when using a compass is to always take your readings away from any metal and to remember the compass points to **magnetic** north, not true north. You can get a rough compensation value from the generalized magnetic variation chart in **Appendix A** or better yet look again at the quadrangle map you used to determine your coordinates. The **local magnetic variation** will be printed **along the edge** of the map. The local surveyor should also have that data. **Re-position** your compass so the needle is pointing away from the **N** symbol the exact number of correction degrees. The N symbol will then be pointing at true north.

Which side of north you should position the needle should be apparent from the diagram on the map. You can be sure of yourself if you remember that **very generally** your compass needle should be on the right side of the N symbol if you are **west** of Wisconsin, Cincinnati, Ohio and Savannah, Georgia. Otherwise the compass needle should be on the left side of the N symbol. It is hard to generalize here without being totally wrong. Your best bet is to check the maps, your surveyor or the local airport.

Is there a better way to find the correct azimuth? Yes, if it's a clear night. All you do is position a stake North of your antenna site and stand South of the stake with another stake in your hand as seen in **figure 21**. The height of the first stake should be about 4 feet and taller perhaps if you live **above** 40 degrees North latitude. A broom or a rake leaning upright against a lawn chair works rather well. All you do is sight the **Pole** star along the top of both stakes and then drive the short stake into the ground. A **line between the two stakes** is a true north south line. A compass on that line with the N and S lined up (ignore the needle) will give you true positional readings.

Fine, but where the heck is Polaris? All you have to do is look at the star map in **Appendix B**. You may notice many pointer stars marked on the map in as much as the position of the constellations vary throughout the evening. You can **rotate the map** until the positions agree for your season or time of night (about **8 PM LST**) and then locate the **Pole** star from the constellation pointers. The Big Dipper is an easy find. It's like a spoon. The two stars at the lip of the spoon are in a **straight line to Polaris**. Another way is to look for the Little Dipper, a bent spoon. **The tip** of the handle is Polaris.

You might find this method is difficult if you live at far northern latitudes. The stake needs to be kinda tall. The easy trick to use here if you've already installed your dish is to simply sight over your dish itself as an index seen in **figure 22**. You can tilt it back so the LNA or feedpoint is visible above the dish or simply put a mark at the top.

FIGURE 21 FINDING TRUE NORTH

Line up the tip of the broom and the tip of the stick with the pole star. A line between the two is your North/South bearing.

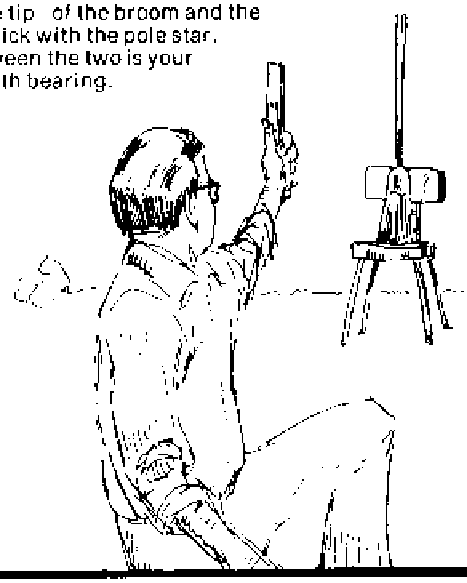
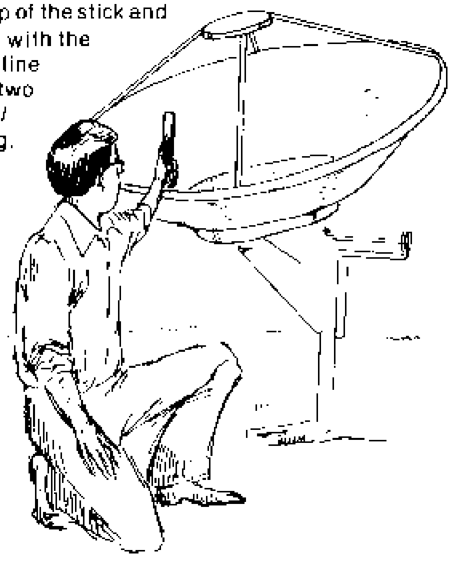


FIGURE 22 USE THE DISH AS A GUIDE

Line up the tip of the stick and the LNA feed with the Pole Star. A line between the two is your North/South bearing.

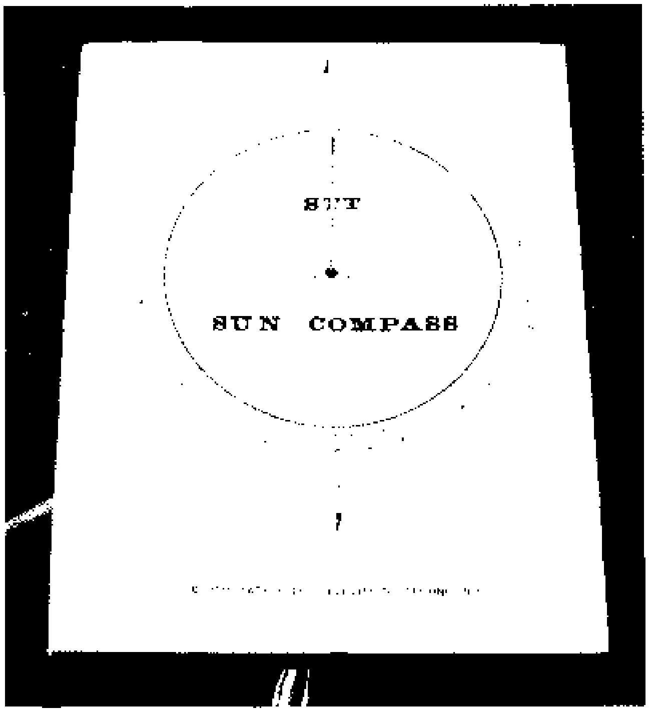


What if it's cloudy at night and you don't have a compass? Here is where we really need to apply some savvy and some math mumbo-jumbo. The effort is greater, but so are the rewards because we will not only find the north and south directions, but the satellite as well!

SHOOTING BIGGER STARS

Using the sun's shadow, we can find a true north line as well as all the bearing positions. In fact we can very accurately find **each** satellite **from the shadow** cast by your LNA feedpoint **on the antenna** using the STT cut-out **Sun Compass** and the **STT Sun Shot Charts**. An extra bonus from learning how to use the charts (easy stuff) is that we can determine when we will experience sun transit outage for each satellite!

Cut out the **STT Sun Compass** at the **back** of this manual. Position it over a piece of stiff cardboard or wood and mark the general area of the center. Drive a long nail through the material from the back. Position the compass over the pointer and glue it to the wood. The nail will act as a pointer and must be sturdily in place as well as the exact center. Redrive the nail if you miss the center.

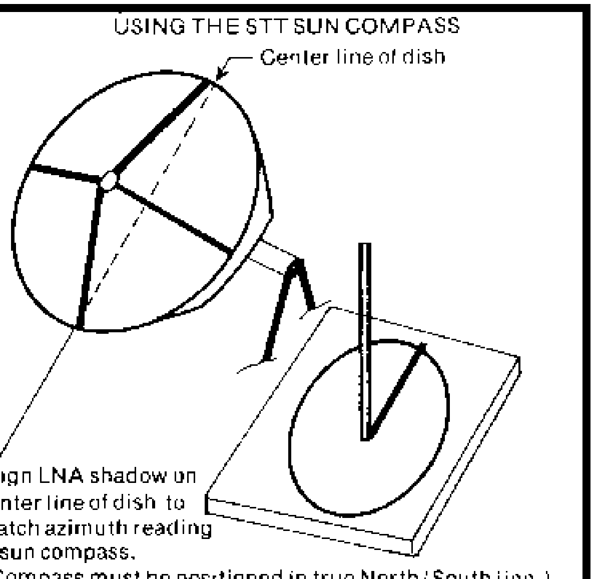


STT SUN COMPASS is a dream come true in the azimuth alignment department. Once this simple instrument [see inside back cover] is tuned to a north/south line its shadow will help you align the antenna using the shadow cost by your LNA as a guide.

USING THE STT SUN COMPASS

The pointer (gnomon in sun dial lingo) casts a shadow that will tell us the relative azimuth of the sun if the sun compass is aligned on a true north/south line. But wait! A shadow that may fall at 200 degrees on the sun compass will also cast (prime

USING THE STT SUN COMPASS



Align LNA shadow on center line of dish to match azimuth reading of sun compass.

(Compass must be positioned in true North/South line.)

FIGURE 23

focus mounted) **LNA shadow** on the dish. And it may indeed fall right in the vertical center line of our dish when it is pointed at 200 degrees true. **Aha!** All we need to do is wait for the sun's shadow to touch the azimuth position we want on the compass, then spin the dish until the LNA shadow falls on a line up the middle.

This may sound like a dream come true (especially on days when the sun is shining clearly). Otherwise you must resort to the more untrustworthy magnetic compass or use the pole star method at night. By the way, you can use the **STT Sun Compass** at night as a much better bearing indicator due to it's size. Simply set the compass on the north/south bearing line you found by using the stakes and point the dish using a line across the compass surface or wait for the sun to cast a shadow as a pointer indicator.

Positioning the sun compass by day may take some effort, but the benefits it can bring you are surely worth the effort. Your first thoughts may be that the shadow should rest on zero degrees or true north at high noon. You are partly correct. Unfortunately, the sun keeps lousy time and it will only point at true north at high noon about 4 times a year. That's not too accurate. Especially when it can be off by nearly 16 minutes in early November! What we need is a cheat sheet such as the **STT Sun Shot Charts** to get us accurate positional info for various times throughout the year. If we then apply a couple of simple corrections for your location we can get accuracy better than a degree...enough to put you just about 'on boresight' in one clean shot!

SUN ORBIT MECHANICS IN A NUTSHELL

Perhaps you're wondering why we need sun position charts or annoying corrections to our time at all. The plain truth is that our sun is in the wrong spot at noon about 361 days a year. Not too good if we must use it to aim our antenna. One of the problems that cause this mishap is that the earth's orbit is not an exact circle around the sun. It's more like an ellipse (egg shaped). To make matters worse, the sun isn't in the middle. So we have days that are longer than others which causes the sun to miss the clock noon mark pretty often. Add to this the fact the earth is tilted on it's axis which makes the sun appear to be at different elevations at noon throughout the year and you begin to wonder how those guys who used to make sundials ever sold any at all!

The up and down action of the sun **(called declination)** doesn't matter much as far as finding azimuth unless you want to use it to check your inclinometer, so we'll ignore it. The other problem with solar positioning is knowing what time it is at your location. When is it noon? As you know our clocks are set to the local time zone meridian and are reading correctly when read on **that** merdian. If you are standing east or west by a measured amount, your clock is wrong by that amount: which is about 4 minutes for every degree you are away from the meridian. While not exactly correct, **the noontime sun is early to those standing east of the meridian. It's late if you are west of the meridian.**

Let's say you are at 75 degrees west and the time zone meridian is also 75 degrees west. Further, at noon on this day, the sun is right on time and hanging out there at 75 degrees. Your clock shows noon and the sun is on time. Big deal. But suppose you are now at 76 degrees west at the same time **(noon)** on your clock. Something is wrong. The sun doesn't seem to be hanging over you situated at 76 degrees, but your clock shows noon! It will take the sun 4 minutes to get to you. So in fact your clock will probably show 12:04 when the sun is directly overhead at your position at 76 west. The sun is late because you are west of the meridian. Some days the sun is early. Who can you trust?

USING THE STT SUN SHOT CHARTS

All we need to do is calculate the correct clock time for our longitude and read the chart for our latitude to the nearest date at the corrected hour. Getting our clock to read the time at our location is a simple matter and finding a chart close to our latitude is even easier. Let's do it step by step.

1]FIGURE THE CORRECT CLOCK TIME:

It's easy to figure the true local time correction for your location by simply adding or subtracting 4 minutes for every degree you are east or west of the meridian. In our example above we added 4 minutes to the clock because we were 1 degree **west** of the time meridian. Subtract 4 minutes for each degree **east** of the meridian. Try to think of it as the sun arriving early if you are east. If you are west, the sun will take longer to get there. **Remember** to get **off Daylight Savings Time** back to **Standard Time!**

Four 'common' standard time meridians are:

75 degrees	EASTERN
90 degrees	**CENTRAL**
105 degrees	MOUNTAIN
120 degrees	**PACIFIC**

Here is another way to do it. Apply a formula and not bother with understanding why it works:

(your longitude) - (nearest time meridian) x 4 = Correction

Then... Correction + clock time = True local time. **Be careful with the sign (+ OR -) of these numbers.** Advance or retard your watch according to the sign.

What is the correction to a clock located at 118 degrees on July 4th?

1)Find difference in degrees longitude. Nearest meridian is Pacific at 120 degrees. 118 - 120 = -2 degrees.

2)Multiply by 4 minutes per degree and add. -2 x 4 = -8 minutes.

So...12 noon Pacific Daylight Savings Time is really 11 AM PST.

And...11 AM plus -8 minutes is 10:52 Local time!

2]SET YOUR WATCH TO THIS NEW CORRECTED LOCAL TIME:

Dumb as it sounds, this should make it easier for you to read the charts.

3]NOW FIND THE CHART FOR YOUR LATITUDE:

The charts are set up in 5 degree intervals from 30 to 50 degrees. Find the chart that is nearest your latitude.

4]ENTER THE CHART AT THE NEAREST DATE:

The charts are arranged in 15 day intervals for a whole year. Pick the day closest to **today**.

5]Move over to the vertical column corresponding to the nearest hour read on your watch and read the azimuth. The intersecting lines of Date and Time will give you the azimuth bearing of the sun to True North. The elevation is also given as a check for your inclinometer.

Okay, it works. Now how do we find a satellite with it? Just wait until the sun's azimuth is the same azimuth as the satellite we seek! **Then position the dish** as we did with the **STT Sun Compass** so the **LNA casts a shadow** somewhere along an imaginary vertical line down **through the center** of the dish.

Why not use the **STT Sun Compass** to verify dish position?

For instance, here in Hollywood, California the azimuth bearing for Satcom I is about 208 degrees true. We can either calibrate the **STT Sun Compass** and wait for the sun to hit 208 degrees, then swing the dish into line or we can find the time the sun will hit 208 degrees from the charts for our date and point the dish at the sun at that time. **Either** way will work and a quick adjustment for elevation should be all that's necessary. In fact it is possible to point the dish using only the sun and never once look at a TV. At the very worst you should be within a few degrees. A fine-tune rocking of the dish will in almost all situations bring instant success.

IMPROVING CHART ACCURACY

The **STT Sun Shot Charts** are accurate within .5 degree through the year 2000. The way you reach the limits of this accuracy is to carefully calculate your position and time of sighting on the sun.

The 1st and 15th of the month are best because the chart was generated for those dates. Of course you can interpolate. Notice how few the degrees change from month to month at the same hour. Interpolation can be easy. But the azimuth change on any day looks irregular from hour to hour...and it is. So your best bet is to stay as close to the hour as possible.

Setting your watch to the corrected time can solve the problem of forgetting how to apply the correction. Use a shortwave receiver tuned to WWV or WWVH or CHU to get

STT SUN POSITION CHART FOR 30 DEGREES LATITUDE

SUN AZIMUTH AND ELEVATION IN DEGREES - - TIME IS LOCAL STANDARD TIME BUT YOU MUST MAKE CORRECTION FOR LONGITUDE

DATE	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM
1/ 1	109.3A -13.2E	116.1A -1.2E	124.2A 10E	134A 20.1E	146.1A 28.4E	160.6A 34.3E	177.4A 36.1E	194.4A 35.4E	207.8A 30.4E	222.6A 22.8E	233A 13.1E	241.5A 2.2E	248.6A -9.6E
1/15	107A -13.4E	113.8A -1.2E	121.9A 10.3E	131.6A 20.7E	143.7A 29.4E	150.4A 35.8E	175.7A 38.7E	193.5A 37.6E	209.6A 32.7E	223A 25.1E	233.7A 15.4E	242.4A 4.5E	249.7A -7.6E
2/ 1	102.9A -12.1E	109.9A .4E	118.1A 12.2E	128A 23.1E	140.3A 32.4E	156.8A 39.4E	174.3A 42.1E	194.7A 41.7E	211.1A 36.7E	225.3A 28.8E	236.4A 18.6E	245.3A 7.2E	252.9A -5E
2/15	99.1A -9.9E	106.2A 2.9E	114.5A 15E	124.6A 26.2E	137.3A 36E	153.7A 43.6E	174A 47.1E	195.3A 46E	213.9A 40.4E	228.8A 32E	240.1A 21.4E	249.1A 9.6E	256.8A -2.9E
3/ 1	94.4A -6.4E	101.7A 6.7E	110.1A 19.1E	120.3A 30.8E	133.6A 41.1E	151.5A 49.3E	174.5A 53E	198.8A 51.4E	219A 44.9E	234.4A 35.6E	245.6A 24.3E	254.5A 12E	262.2A .7E
3/15	90.4A -2.7E	97.6A 10.5E	106.1A 23.1E	116.3A 35.2E	130A 46E	149.5A 54.7E	175A 58.5E	203.6A 56.1E	225A 48.6E	240.4A 38.4E	251.2A 26.5E	259.9A 13.9E	267.5A 1E
4/ 1	85.6A 1.8E	93.2A 14.7E	101.5A 27.5E	111.6A 39.9E	125.3A 51.5E	146.9A 60.5E	[illegible] 64.9E	210.5A 60.9E	233.3A 52.3E	247.5A 41E	257.6A 28.5E	265.8A 15.6E	273.6A 2.7E
4/15	81.8A 5.4E	89.2A 18.3E	97.1A 31.2E	106.8A 43.8E	120.3A 55.9E	143.6A 65.6E	181.7A 69.5E	218.6A 64.8E	241.1A 54.9E	254.2A 42.9E	263.5A 30.1E	271.2A 17.1E	278.7A 4.2E
5/ 1	77.6A 8.9E	84.7A 21.6E	92.1A 34.6E	101A 47.4E	113.5A 60E	132.8A 70.6E	186. A 74.8E	228.9A 68.4E	249.8A 57.3E	261.3A 44.6E	269.5A 31.7E	276.6A 18.7E	283.9A 6E
5/15	74.4A 11E	81.1A 23.7E	88A 36.6E	96A 49.5E	107.2A 62.3E	130.6A 74.8E	190A 78.6E	237.8A 70.8E	256.5A 58.9E	266.4A 46E	273.8A 33E	280.5A 20E	287.4A 7.5E
6/ 1	71.3A 12.4E	77.7A 24.9E	84.1A 37.7E	91.1A 50.7E	100.5A 63.6E	120.7A 75.8E	192.6A 81.9E	246.3A 72.8E	263.7A 60.4E	270.8A 47.4E	277.4A 34.4E	283.7A 21.6E	290.2A 9.3E
6/15	69.8A 12.5E	76.1A 24.9E	82.2A 37.7E	88.7A 50.6E	97.2A 63.6E	114.6A 76.1E	[illegible] 83.3E	249.6A 71E	264.4A 61.4E	272.4A 48.4E	278.9A 35.5E	284.9A 22.7E	291.1A 10.4E
7/ 1	69.5A 11.7E	75.8A 24.1E	81.9A 36.8E	88.3A 49.8E	96.8A 62.7E	113.7A 75.3E	162.8A 83.4E	248. A 74.8E	264.5A 62.2E	271.9A 49.7E	278.3A 36.2E	284.4A 23.5E	290.6A 11.1E
7/15	70.6A 10.4E	77.1A 22.9E	83.3A 35.7E	90.1A 48.7E	99.4A 61.5E	116.0A 74E	177.6A 81.9E	242A 74.5E	260A 62.3E	269.3A 49.3E	275.5A 36.3E	282.7A 23.5E	289A 11E
8/ 1	73.6A 8.4E	80.3A 21.1E	87A 34E	94.7A 47E	105.6A 59.7E	125. A 71.5E	176.5A 78.4E	231.5A 72.6E	253A 60.9E	264.7A 48.2E	272.2A 35.3E	279.1A 22.4E	285.6A 9.6E
8/15	77.3A 6.6E	84.3A 19.4E	91.5A 32.4E	100A 45.4E	112.5A 57.7E	134.1A 68.7E	178A 74.4E	224.7A 69.5E	246.3A 58.6E	259A 46.2E	267.9A 33.4E	275.3A 20.4E	282.1A 7.5E
9/ 1	82.9A 4.3E	90.2A 17.3E	98A 30.3E	107.6A 43E	121.8A 54.7E	144.4A 64.3E	180.6A 68.4E	216.7A 64.7E	238.8A 54.3E	252.5A 42.5E	262.7A 29.9E	270.2A 17E	277.3A 3.9E
9/15	88.1A 2.4E	95.6A 15.4E	103.9A 28.1E	114.2A 40.6E	129.3A 51.5E	151.5A 59.9E	185.1A 63E	212.7A 59.1E	233.4A 49.9E	247.3A 38.6E	257.5A 26.3E	265.8A 13.5E	273.1A .4E
10/ 1	94.2A .2E	101.8A 13.1E	110.5A 25.6E	121.5A 37.3E	136.8A 47.2E	157.8A 53.4E	184.1A 56.5E	209.3A 52.9E	228.1A 44.4E	241.9A 33.8E	252.2A 21.9E	260.7A 9.3E	268.1A -3.8E
10/15	99.3A -2E	106.9A 10.7E	115.8A 22.8E	126.9A 34E	142A 43.1E	161.5A 49.4E	184.6A 51E	205.8A 47.6E	224.3A 39.7E	237.6A 29.6E	247.9A 18.2E	256.3A 5.9E	263.6A -7.1E
11/ 1	104.6A -4.8E	112.2A 7.6E	121A 19.3E	132A 29.7E	146.4A 38.1E	164.1A 43.6E	184.4A 45E	203.9A 41.9E	220.1A 34.7E	232.9A 25.3E	243A 14.4E	251.3A 2.4E	258.4A -10.2E
11/15	107.9A -7.2E	115.3A 4.9E	124A 16.3E	134.7A 26.4E	148.3A 34.3E	164.9A 39.5E	[illegible] 40.9E	201.5A 38.2E	216.9A 31.6E	229.4A 22.8E	239.3A 12.7E	247.6A .6E	254.5A -11.7E
12/ 1	110.1A -9.8E	117.3A 2.1E	125.7A 13.2E	136A 23.1E	148.9A 30.9E	164.4A 36.1E	181.7A 37.2E	198.8A 35.4E	213.6A 29.6E	226A 21.2E	236A 11.1E	244.2A -.1E	251A -12.1E
12/15	110.6A -11.8E	117.6A .1E	125.8A 11.3E	135.8A 21.1E	149.1A 29E	163A 34.4E	179.8A 36.4E	196.6A 34.5E	211.4A 29.2E	223.3A 21.2E	233.9A 11.4E	242.2A .4E	249.1A -11.4E

STT SUN POSITION CHART FOR 35 DEGREES LATITUDE

SUN AZIMUTH AND ELEVATION IN DEGREES - - TIME IS LOCAL STANDARD TIME BUT YOU MUST MAKE CORRECTION FOR LONGITUDE

DATE	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM
1/ 1	108.2A	116A	124.8A	135.2A	147.5A	161.7A	177.5A	193.6A	208.5A	221.3A	232.2A	241.4A	249.5A
	-14.8E	-3.4E	7.2E	16.6E	24.3E	29.6E	31.8E	30.5E	26.1E	19.1E	10.1E	-.2E	-11.4E
1/15	105.8A	113.6A	122.5A	132.9A	145.2A	159.6A	176A	192.7A	208.2A	221.5A	232.7A	242.1A	250.4A
	-14.8E	-3.2E	7.6E	17.3E	25.3E	31.2E	33.7E	32.7E	28.3E	21.4E	12.4E	2E	-9.3E
2/ 1	101.8A	109.9A	119A	129.5A	142.2A	157.3A	174.7A	192.8A	209.3A	223.5A	235.1A	244.9A	253.4A
	-13.2E	-1.3E	9.8E	19.9E	28.4E	34.8E	37.7E	36.9E	32.3E	25.2E	15.8E	5.1E	-6.4E
2/15	98.2A	106.4A	115.7A	126.4A	139.6A	155.6A	174.5A	194.1A	211.8A	226.7A	238.5A	248.4A	257.1A
	-10.7E	1.5E	12.9E	23.3E	32.2E	39.1E	42.2E	41.1E	36.2E	28.7E	18.8E	7.8E	-4E
3/ 1	93.8A	102.2A	111.7A	122.7A	136.5A	153.9A	175.1A	197A	216.2A	231.7A	243.7A	253.5A	262.3A
	-6.7E	5.6E	17.3E	28.1E	37.5E	44.8E	48E	46.6E	41E	32.6E	22.2E	10.7E	-1.4E
3/15	90A	98.5A	108A	119.3A	133.7A	152.6A	176.5A	201A	221.4A	237.2A	249A	258.7A	267.4A
	-2.7E	9.8E	21.7E	32.8E	42.6E	50.3E	53.5E	51.5E	45E	35.8E	24.8E	13E	.8E
4/ 1	85.8A	94.5A	104A	115.3A	130A	151.1A	178.7A	206.6A	228.5A	243.7A	255A	264.4A	273.4A
	2.1E	14.3E	26.4E	37.9E	48.5E	56.2E	59.4E	56.5E	49.2E	38.9E	27.3E	15.2E	3.1E
4/15	82.3A	90.8A	100.1A	111.2A	126.2A	149.1A	181.4A	212.9A	235.3A	249.9A	260.6A	269.6A	278.3A
	6.1E	18.3E	30.4E	42.2E	53.2E	61.5E	64.5E	60.7E	52.3E	41.3E	29.4E	17.1E	5E
5/ 1	78.4A	86.7A	95.5A	106.2A	120.9A	145.7A	184.6A	220.7A	243A	256.5A	266.4A	274.9A	283.3A
	9.9E	22E	34.2E	46.2E	57.7E	66.6E	69.8E	64.8E	55.3E	43.7E	31.5E	19.2E	7.2E
5/15	75.4A	83.3A	91.7A	101.8A	115.8A	141.3A	187A	227.3A	248.8A	261.3A	270.6A	278.6A	286.7A
	12.3E	24.3E	36.6E	48.7E	60.5E	70.1E	73.6E	67.7E	57.5E	45.4E	33.2E	20.9E	9E
6/ 1	72.5A	80.1A	88A	97.2A	110A	134.8A	187.8A	233.2A	253.8A	265.3A	274A	281.7A	289.4A
	13.9E	25.8E	38E	50.3E	62.3E	72.7E	76.9E	70.3E	59.3E	47.2E	34.9E	22.7E	11E
6/15	71A	78.4A	86.1A	94.8A	106.9A	130.2A	185.8A	235.2A	255.5A	266.8A	275.2A	282.7A	290.2A
	14.1E	26E	38.2E	50.4E	62.5E	73.4E	78.4E	71.7E	60.5E	48.4E	36.1E	23.9E	12.2E
7/ 1	70.6A	78.1A	85.6A	94.3A	106.2A	128.3A	181.6A	233.2A	254.4A	266.1A	274.6A	282.2A	289.6A
	13.4E	25.2E	37.4E	49.7E	61.7E	72.7E	78.4E	72.3E	61.2E	49.1E	36.8E	24.7E	12.9E
7/15	71.6A	79.2A	86.9A	95.8A	108.2A	130.2A	178.5A	228.4A	251A	263.6A	272.6A	280.5A	288A
	12E	23.9E	36.1E	48.4E	60.3E	71.2E	76.9E	71.7E	60.9E	49E	36.7E	24.5E	12.6E
8/ 1	74.4A	82.3A	90.4A	100A	113.4A	135.9A	177.5A	221.1A	244.8A	258.7A	268.6A	277A	284.7A
	9.7E	21.8E	34.1E	46.4E	58E	68.2E	73.4E	69.2E	59.1E	47.5E	35.3E	23.1E	10.9E
8/15	77.9A	86.1A	94.7A	104.9A	119.3A	142A	178.4A	215.9A	239.5A	254A	264.6A	273.4A	281.4A
	7.6E	19.8E	32.1E	44.3E	55.5E	65E	69.4E	65.7E	56.3E	45.1E	33.1E	20.8E	8.5E
9/ 1	83.3A	91.7A	100.9A	111.9A	127.3A	149.5A	180.5A	211.4A	233.3A	248.3A	259.4A	268.6A	276.9A
	4.9E	17.2E	29.5E	41.3E	51.8E	60.1E	63.4E	60.1E	51.5E	40.8E	29.1E	17E	4.5E
9/15	88.3A	96.9A	106.4A	118A	133.7A	155.1A	182.2A	208.8A	229A	243.8A	255.1A	264.6A	273A
	2.6E	14.9E	27E	38.4E	48.2E	55.5E	58E	54.8E	46.7E	36.6E	25.1E	13.1E	.6E
10/ 1	94.2A	102.9A	112.7A	124.5A	140.2A	160.1A	183.6A	206.5A	224.9A	239.1A	250.4A	259.9A	268.4A
	-.2E	12E	23.7E	34.6E	43.5E	49.7E	51.6E	48.4E	40.9E	31.3E	20.3E	8.5E	-3.9E
10/15	99.1A	107.8A	117.6A	129.5A	144.6A	163.7A	184.7A	204.6A	221.7A	235.4A	246.4A	255.9A	264.3A
	-2.8E	9.2E	20.6E	30.9E	39.1E	44.6E	46E	43E	34E	26.9E	16.2E	4.7E	-7.6E
11/ 1	104.1A	112.7A	122.4A	134A	148.3A	165.3A	184A	202.3A	218A	231.1A	243.9A	251.2A	259.3A
	-6E	5.7E	16.6E	26.3E	33.8E	38.8E	40E	37.3E	30.9E	22.3E	12.1E	.8E	-11.2E
11/15	107.2A	115.6A	125.1A	136.3A	149.9A	165.4A	183.2A	200.2A	215.2A	227.9A	239.5A	247.6A	255.6A
	-8.7E	2.8E	13.4E	22.8E	30E	34.7E	35.9E	33.5E	27.6E	19.5E	9.7E	-1.3E	-13E
12/ 1	109.2A	117.4A	126.6A	137.4A	150.3A	165.2A	181.5A	197.7A	212.2A	224.7A	235.2A	244.3A	252.1A
	-11.5E	-.2E	10.2E	19.4E	26.6E	31.3E	32.7E	30.7E	25.4E	17.7E	8.3E	-2.3E	-13.7E
12/15	109.5A	117.5A	126.5A	137A	149.4A	163.9A	179.6A	195.7A	210.1A	222.6A	233.7A	242.3A	250.2A
	-13.5E	-2.2E	8.2E	17.4E	24.7E	29.6E	31.4E	29.7E	24.9E	17.6E	8.5E	-2E	-13.2E

STT SUN POSITION CHART FOR 40 DEGREES LATITUDE

SUN AZIMUTH AND ELEVATION IN DEGREES - - TIME IS LOCAL STANDARD TIME BUT YOU MUST MAKE CORRECTION FOR LONGITUDE

DATE	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM
1/ 1	106.8A	115.6A	125.3A	136.1A	148.5A	162.4A	177.6A	193A	207.5A	220.3A	231.6A	241.5A	250.5A
	-16.3E	-5.6E	4.3E	13E	20E	24.8E	26.8E	25.7E	21.6E	15.3E	7E	-2.6E	-13.1E
1/15	104.4A	113.3A	123A	133.9A	146.4A	160.6A	176.2A	192.1A	207A	220.4A	231.9A	242.1A	251.3A
	-16.1E	-5.2E	4.9E	13.9E	21.2E	26.4E	28.7E	27.8E	23.9E	17.7E	9.3E	-.4E	-11E
2/ 1	100.7A	109.7A	119.6A	130.8A	143.7A	158.5A	175.1A	192A	207.9A	222.1A	234.1A	244.5A	254A
	-14.2E	-3E	7.4E	16.7E	24.5E	30.2E	32.8E	32E	27.9E	21.5E	12.9E	3E	-7.8E
2/15	97.2A	106.5A	116.6A	128A	141.4A	157.1A	174.9A	193.1A	210A	224.8A	237.2A	247.8A	257.5A
	-11.4E	0E	10.7E	20.3E	28.4E	34.5E	37.2E	36.3E	32E	25.2E	16.2E	5.9E	-5.1E
3/ 1	93.2A	102.7A	113A	124.8A	138.9A	155.9A	175.5A	195.6A	213.9A	229.4A	242A	252.7A	262.4A
	-7E	4.5E	15.4E	25.4E	33.8E	40.3E	43E	41.8E	36.9E	29.4E	19.9E	9.2E	-2E
3/15	89.8A	99.3A	109.8A	121.9A	136.7A	155.1A	176.8A	199A	218.4A	234.3A	246.9A	257.6A	267.3A
	-2.7E	9E	20E	30.3E	39.1E	45.8E	48.5E	46.8E	41.2E	30E	22.9E	12E	.5E
4/ 1	86A	95.8A	106.3A	118.6A	134A	154.2A	178.9A	203.6A	224.5A	240.2A	252.6A	263.1A	273.1A
	2.5E	13.9E	25.1E	35.6E	45.1E	51.8E	54.4E	52E	45.7E	36.5E	26E	14.7E	3.3E
4/15	82.8[illegible]	92.5A	102.9A	115.3A	131.1A	153.2A	181.2A	208.7A	230.4A	245.9A	257.9A	268.1A	277.9A
	6.7E	18.1E	29.4E	40.2E	50.1E	57.1E	59.5E	56.4E	49.3E	39.4E	28.5E	17E	5.7E
5/ 1	79.3A	88.7A	98.8A	111A	127.1A	150.2A	183.8A	214.7A	237A	252A	263.4A	273.2A	282.6A
	10.9E	22.2E	33.6E	44.6E	54.9E	62.4E	64.8E	60.9E	52.7E	42.3E	31.1E	19.5E	8.3E
5/15	76.5A	85.6A	95.4A	107.2A	123.1A	148.5A	185.4A	219.6A	241.9A	256.4A	267.3A	276.7A	285.9A
	13.5E	24.8E	36.3E	47.5E	58E	66E	68.6E	64.1E	55.2E	44.5E	33.1E	21.6E	10.4E
6/ 1	73.7A	82.5A	91.9A	103A	118.3A	144.1A	185.7A	223.6A	246.1A	260A	270.5A	279.5A	288.4A
	15.4E	26.6E	38E	49.4E	60.2E	68.9E	72E	67E	57.6E	46.6E	35.1E	23.7E	12.6E
6/15	72.2A	80.9A	90A	100.8A	115.5A	140.8A	184.1A	224.6A	247.3A	261.2A	271.5A	280.5A	289.1A
	15.7E	26.9E	38.3E	49.8E	60.7E	69.8E	73.4E	68.5E	58.9E	47.8E	36.4E	24.9E	13.9E
7/ 1	71.8A	80.4A	89.5A	100.1A	114.6A	138.8A	181.1A	222.6A	246.1A	260.4A	270.9A	279.9A	288.5A
	15E	26.1E	37.6E	49E	60E	69.3E	73.4E	68.9E	59.5E	48.5E	37.1E	25.6E	14.5E
7/15	72.7A	81.4A	90.6A	101.3A	116A	139.6A	178.9A	218.9A	243A	257.9A	268.9A	278.2A	286.8A
	13.5E	24.7E	36.2E	47.7E	58.5E	67.6E	71.9E	68E	59E	48.2E	36.8E	25.3E	14.1E
8/ 1	75.3A	84.3A	93.8A	105A	120.3A	143.3A	178.1A	213.9A	237.8A	253.5A	265.1A	274.8A	283.8A
	11E	22.4E	33.9E	45.3E	55.7E	64.4E	68.4E	65.2E	56.7E	46.3E	35E	23.6E	12.2E
8/15	78.6A	87.9A	97.8A	109.4A	125.2A	147.6A	178.7A	210.4A	233.4A	249.4A	261.4A	271.5A	280.7A
	8.6E	20.1E	31.6E	42.8E	52.9E	60.9E	64.4E	61.5E	53.5E	43.5E	32.5E	21.1E	9.5E
9/ 1	83.8A	93.3A	103.6A	115.8A	131.9A	153.4A	180.4A	207.5A	228.6A	244.4A	256.7A	267.1A	276.5A
	5.5E	17E	28.4E	39.3E	48.6E	55.7E	58.4E	55.7E	48.3E	38.8E	28.1E	16.8E	5.1E
9/15	88.5A	98.2A	108.8A	121.3A	137.4A	157.7A	181.9A	205.8A	225.3A	240.7A	252.9A	263.4A	273A
	2.7E	14.2E	25.4E	35.9E	44.6E	50.9E	53E	50.3E	43.3E	34.2E	23.8E	12.6E	.9E
10/ 1	94.2A	103.9A	114.6A	127.2A	142.9A	161.8A	183.2A	204.2A	222.1A	236.7A	248.7A	259.2A	268.7A
	-.6E	10.8E	21.7E	31.6E	39.5E	45E	46.6E	43.9E	37.3E	28.7E	18.5E	7.6E	-4.1E
10/15	98.8A	108.5A	119.2A	131.6A	146.8A	164.4A	183.9A	202.9A	219.5A	233.4A	245.2A	255.5A	264.9A
	-3.6E	7.6E	18.2E	27.6E	34.9E	39.8E	41.1E	38.5E	32.2E	24E	14.2E	3.4E	-8.1E
11/ 1	103.6A	113.1A	123.5A	135.6A	149.9A	166.2A	183.8A	201A	216.4A	229.7A	241.1A	251.2A	260.3A
	-7.2E	3.7E	13.9E	22.8E	29.5E	33.9E	35E	32.6E	26.9E	19.1E	9.7E	-.8E	-12.1E
11/15	106.4A	115.7A	125.9A	137.6A	151.2A	166.6A	183A	199.2A	213.8A	226.7A	237.9A	247.8A	256.8A
	-10.2E	.6E	10.5E	19.1E	25.6E	29.8E	31E	28.8E	23.5E	16.1E	7E	-3.2E	-14.2E
12/ 1	108.2A	117.3A	127.2A	138.4A	151.4A	165.9A	181.5A	196.9A	211.1A	223.7A	234.7A	244.5A	253.4A
	-13.1E	-2.5E	7.2E	15.7E	22.2E	26.4E	27.7E	25.9E	21.1E	14.2E	5.5E	-4.4E	-15.2E
12/15	108.3A	117.2A	127A	138A	150.5A	164.6A	179.8A	195A	209.1A	221.7A	232.7A	242.5A	251.3A
	-15.1E	-4.5E	5.2E	13.7E	20.4E	24.8E	26.4E	24.9E	20.6E	13.9E	5.4E	-4.3E	-14.8E

STT SUN POSITION CHART FOR 45 DEGREES LATITUDE

SUN AZIMUTH AND ELEVATION IN DEGREES - - TIME IS LOCAL STANDARD TIME BUT YOU MUST MAKE CORRECTION FOR LONGITUDE

DATE	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM
1/ 1	105.4A	115.1A	125.5A	136.8A	149.4A	163.1A	177.7A	192.5A	206.6A	219.5A	231.2A	241.8A	251.7A
	-17.7E	-7.8E	1.4E	9.4E	15.7E	20E	21.8E	20.8E	17.2E	11.5E	3.9E	-5E	-14.8E
1/15	103A	112.8A	123.3A	134.7A	147.4A	161.3A	176.3A	191.6A	206.1A	219.4A	231.4A	242.2A	252.3A
	-17.3E	-7.1E	2.2E	10.4E	17E	21.7E	23.7E	22.9E	19.4E	13.8E	6.2E	-2.7E	-12.5E
2/ 1	99.4A	109.4A	120.1A	131.8A	144.9A	159.4A	175.3A	191.5A	206.8A	220.9A	233.3A	244.4A	254.7A
	-15.1E	-4.7E	4.9E	13.4E	20.4E	25.5E	27.8E	27.1E	23.5E	17.8E	9.9E	.8E	-9.2E
2/15	96.2A	106.4A	117.3A	129.4A	143A	158.3A	175.2A	192.4A	208.6A	223.3A	236.1A	247.4A	257.9A
	-12E	-1.4E	8.4E	17.2E	24.4E	29.9E	32.2E	31.4E	27.6E	21.6E	13.4E	4E	-6.2E
3/ 1	92.6A	103A	114.2A	126.6A	140.9A	157.4A	175.8A	194.6A	217A	227.4A	240.5A	252A	262.6A
	-7.3E	3.4E	13.4E	22.4E	30E	35.7E	38.1E	37E	32.7E	26.1E	17.5E	7.7E	-2.7E
3/15	89.6A	100.1A	111.5A	124.3A	139.3A	157A	177.1A	197.5A	215.9A	231.9A	245.1A	256.6A	267.3A
	-2.7E	8.2E	18.3E	27.5E	35.3E	41.2E	43.5E	42.1E	37.2E	30E	20.9E	10.8E	.3E
4/ 1	86.3A	97A	108.5A	121.6A	137.3A	156.7A	179A	201.4A	221.3A	237.2A	250.4A	261.8A	272.8A
	2.8E	13.3E	23.6E	33.1E	41.5E	47.2E	49.4E	47.4E	42.1E	33.9E	24.4E	14E	3.6E
4/15	83.4A	94.1A	105.6A	118.9A	135.2A	156.2A	181A	205.5A	226.3A	242.3A	255.3A	266.5A	277.3A
	7.3E	17.8E	28.2E	37.9E	46.6E	52.5E	54.5E	52E	46E	37.3E	27.3E	16.8E	6.4E
5/ 1	80.3A	90.7A	102.1A	115.4A	132.3A	155.2A	183.2A	210.3A	231.9A	247.8A	260.4A	271.4A	281.9A
	11.7E	22.2E	32.7E	42.7E	51.7E	57.9E	59.8E	56.7E	49.8E	40.6E	30.4E	19.7E	9.4E
5/15	77.7A	87.9A	99A	112.2A	129.2A	153.4A	184.4A	213.9A	236A	251.8A	264.1A	274.7A	284.9A
	14.6E	25.1E	35.6E	45.8E	55.1E	61.7E	63.7E	60.1E	52.7E	43.1E	32.7E	22.1E	11.7E
6/ 1	75.1A	85A	95.8A	108.5A	125.4A	150.5A	184.5A	216.7A	239.3A	254.9A	267A	277.3A	287.2A
	16.7E	27.1E	37.7E	48E	57.6E	64.7E	67E	63.1E	55.3E	45.5E	35E	24.4E	14.1E
6/15	73.7A	83.4A	94A	106.4A	122.9A	147.9A	183.7A	217A	240.2A	255.9A	267.8A	278.1A	287.9A
	17.2E	27.6E	38.2E	48.6E	58.2E	65.7E	68.4E	64.7E	56.7E	46.9E	36.3E	25.8E	15.5E
7/ 1	73.1A	82.9A	93.3A	105.6A	121.9A	146.1A	180.8A	215.2A	238.9A	254.9A	267.1A	277.5A	287.2A
	16.5E	26.9E	37.5E	47.9E	57.6E	65.3E	68.4E	65E	57.2E	47.4E	37E	26.4E	16E
7/15	73.9A	83.7A	94.2A	106.5A	122.8A	146.3A	179.1A	212.4A	236.2A	252.7A	265.2A	275.8A	285.6A
	14.9E	25.4E	36E	46.5E	56E	63.6E	66.9E	64E	56.4E	46.9E	36.5E	25.9E	15.5E
8/ 1	76.3A	86.4A	97.1A	109.7A	126.1A	148.6A	170.4A	208.7A	231.9A	248.7A	261.7A	272.6A	282.6A
	12.3E	22.8E	33.4E	43.8E	53E	60.3E	63.4E	60.9E	53.8E	44.7E	34.5E	23.9E	13.3E
8/15	79.4A	89.7A	100.7A	113.6A	130.2A	151.8A	178.9A	206.4A	228.4A	245.1A	258.3A	269.6A	279.8A
	9.6E	20.2E	30.8E	41E	49.8E	56.6E	59.4E	57.1E	50.4E	41.6E	31.6E	21.1E	10.4E
9/ 1	84.3A	94.8A	106.1A	119.3A	135.8A	156.2A	180.3A	204.5A	224.8A	241A	254.2A	265.6A	276.1A
	6E	16.6E	27.1E	37E	45.2E	51.2E	53.4E	51.2E	44.9E	36.5E	26.8E	16.5E	5.7E
9/15	88.8A	99.4A	110.9A	124.2A	140.4A	159.8A	181.7A	203.4A	222.3A	237.9A	250.9A	262.3A	272.9A
	2.8E	13.4E	23.7E	33.2E	40.8E	46.2E	48E	45.8E	39.7E	31.7E	22.2E	12E	1.2E
10/ 1	94.1A	104.8A	116.3A	129.4A	145.2A	163.2A	183A	207.5A	219.7A	234.6A	247.3A	258.6A	269.1A
	-.9E	9.6E	19.6E	28.5E	35.5E	40.2E	41.6E	39.3E	33.3E	25.8E	16.7E	6.6E	-4.1E
10/15	98.5A	109.1A	120.5A	133.4A	148.5A	165.4A	183.6A	201.5A	217.6A	231.8A	244.1A	255.3A	265.7A
	-4.3E	6E	15.7E	24.3E	30.7E	35E	36.1E	33.8E	28.3E	20.9E	12E	2.2E	-8.5E
11/ 1	102.9A	113.3A	124.5A	136.9A	151.2A	166.9A	183.6A	200A	215A	228.5A	240.4A	251.3A	261.4A
	-8.4E	1.7E	11.1E	19.2E	25.2E	29.1E	30E	27.9E	22.8E	15.8E	7.2E	-2.4E	-12.8E
11/15	105.5A	115.7A	126.6A	138.7A	152.3A	167.2A	182.9A	198.4A	212.7A	225.8A	237.5A	248.1A	258.1A
	-11.6E	-1.6E	7.5E	15.4E	21.2E	25E	26E	24.1E	19.3E	12.6E	4.4E	-5E	-15.3E
12/ 1	107A	117A	127.6A	139.3A	152.2A	166.4A	181.4A	196.3A	210.2A	223A	234.5A	245A	254.7A
	-14.7E	-4.8E	4.2E	11.9E	17.8E	21.6E	22.7E	21.1E	16.8E	10.5E	2.6E	-6.6E	-16.6E
12/15	107A	116.8A	127.2A	138.7A	151.3A	165.1A	179.8A	194.5A	208.2A	221A	232.4A	242.9A	252.7A
	-16.6E	-6.8E	2.2E	10E	16E	20E	21.4E	20.1E	16.2E	10.1E	2.4E	-6.6E	-16.3E

STT SUN POSITION CHART FOR 50 DEGREES LATITUDE

SUN AZIMUTH AND ELEVATION IN DEGREES - - TIME IS LOCAL STANDARD TIME BUT YOU MUST MAKE CORRECTION FOR LONGITUDE

DATE	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM
1/ 1	103.8A	114.4A	125.5A	137.3A	150A	163.5A	177.8A	192.2A	206A	219A	231A	242.2A	253A
	-19E	-9.9E	-1.5E	5.7E	11.4E	15.2E	16.8E	15.9E	12.7E	7.6E	.8E	-7.3E	-16.3E
1/15	101.4A	112.1A	123.3A	135.2A	148.1A	161.8A	176.5A	191.2A	205.4A	218.8A	231.1A	242.5A	253.4A
	-18.4E	-9.1E	-.6E	6.8E	12.8E	17E	18.7E	18E	14.9E	10E	3.1E	-5E	-14E
2/ 1	98A	108.9A	120.4A	132.6A	145.8A	160.2A	175.5A	191A	206A	219.9A	232.7A	244.4A	255.5A
	-15.8E	-6.3E	2.4E	10E	16.3E	20.8E	22.8E	22.2E	19E	14E	6.9E	-1.3E	-10.5E
2/15	95.1A	106.2A	117.9A	130.4A	144.2A	159.2A	175.4A	191.8A	207.5A	222.1A	235.2A	247.2A	258.5A
	-12.5E	-2.8E	6.1E	13.9E	20.4E	25.2E	27.2E	26.5E	23.2E	17.9E	10.6E	2.1E	-7.2E
3/ 1	91.9A	103.3A	115.2A	128.2A	142.6A	158.7A	176.1A	193.7A	210.4A	225.8A	239.2A	251.4A	262.9A
	-7.5E	2.3E	11.3E	19.4E	26.1E	31.1E	33.1E	32.1E	28.4E	22.7E	15E	6.1E	-3.3E
3/15	89.3A	100.8A	112.9A	126.3A	141.4A	158.5A	177.3A	196.3A	213.9A	229.8A	243.4A	255.7A	267.3A
	-2.6E	7.2E	16.4E	24.6E	31.5E	36.6E	38.5E	37.3E	33.1E	26.9E	18.7E	9.7E	.1E
4/ 1	86.5A	98.1A	110.5A	124.2A	140A	158.6A	179.1A	199.6A	218.5A	234.6A	248.3A	260.6A	272.4A
	3.1E	12.7E	21.9E	30.3E	37.8E	42.6E	44.4E	42.7E	38.2E	31.1E	22.6E	13.3E	3.8E
4/15	84.1A	95.7A	108.1A	122.1A	138.6A	158.5A	180.9A	203.1A	222.9A	239.2A	252.9A	265A	276.8A
	7.9E	17.4E	26.8E	35.4E	43E	47.9E	49.6E	47.4E	42.4E	34.8E	26E	16.5E	7E
5/ 1	81.4A	92.8A	105.1A	119.3A	136.5A	158.1A	182.8A	206.9A	227.6A	244A	257.6A	269.6A	281A
	12.5E	22.1E	31.5E	40.4E	48.2E	53.3E	54.8E	52.3E	46.6E	38.6E	29.4E	19.8E	10.4E
5/15	79.1A	90.3A	102.5A	116.7A	134.3A	157A	183.8A	209.7A	231A	247.5A	260.9A	272.7A	283.9A
	15.6E	25.2E	34.7E	43.7E	51.7E	57.1E	58.7E	55.8E	49.7E	41.4E	32E	22.4E	13E
6/ 1	76.6A	87.6A	99.6A	113.6A	131.2A	154.9A	183.7A	211.6A	233.6A	250.2A	263.5A	275A	286A
	17.9E	27.4E	37E	46.2E	54.4E	60.2E	62E	59E	52.6E	44E	34.6E	24.9E	15.6E
6/15	75.2A	86.1A	97.8A	111.6A	129.1A	152.9A	182.6A	211.5A	234.1A	250.9A	264.2A	275.7A	286.5A
	18.5E	28E	37.6E	46.9E	55.3E	61.4E	63.4E	60.5E	54E	45.4E	36E	26.4E	17E
7/ 1	74.6A	85.5A	97.1A	110.7A	128A	151.3A	180.7A	209.9A	232.8A	249.9A	263.4A	275A	285.7A
	17.9E	27.4E	37E	46.4E	54.7E	61E	63.4E	60.8E	54.4E	45.9E	36.6E	26.9E	17.5E
7/15	75.2A	86.1A	97.8A	111.4A	128.5A	151.1A	179.3A	207.7A	230.4A	247.8A	261.5A	273.3A	284.2A
	16.3E	25.8E	35.5E	44.8E	53.1E	59.4E	61.9E	59.6E	53.4E	45.2E	35.9E	26.3E	16.8E
8/ 1	77.4A	88.5A	100.4A	114A	131A	152.6A	178.6A	205A	227A	244.3A	258.3A	270.4A	281.4A
	13.4E	23E	32.7E	41.9E	49.9E	55.9E	58.4E	56.5E	50.6E	42.7E	33.6E	24.1E	14.4E
8/15	80.3A	91.6A	103.6A	117.4A	134.3A	154.9A	179A	203.4A	224.3A	241.3A	255.4A	267.6A	278.8A
	10.5E	20.1E	29.7E	38.8E	46.4E	52.1E	54.4E	52.6E	46.9E	39.3E	30.4E	21E	11.2E
9/ 1	84.8A	96.3A	108.5A	122.3A	139A	158.4A	180.3A	202.2A	221.6A	237.9A	251.8A	264.2A	275.5A
	6.5E	16.2E	25.6E	34.4E	41.5E	46.6E	48.4E	46.7E	41.3E	34E	25.4E	16E	6.2E
9/15	89A	100.6A	112.9A	126.7A	142.9A	161.4A	181.5A	201.6A	219.7A	235.4A	249A	261.3A	272.7A
	2.9E	12.6E	21.9E	30.3E	36.9E	41.5E	43E	41.2E	35.9E	28.9E	20.5E	11.3E	1.4E
10/ 1	94A	105.5A	117.8A	131.4A	147A	164.3A	182.8A	201.1A	217.8A	232.7A	246A	258.1A	269.4A
	-1.3E	8.3E	17.3E	25.3E	31.3E	35.4E	36.6E	34.7E	29.6E	22.9E	14.7E	5.6E	-4.2E
10/15	98.1A	109.5A	121.6A	134.9A	149.9A	166.2A	183.4A	200.4A	216.1A	230.4A	243.3A	255.2A	266.4A
	-5E	4.4E	13.1E	20.8E	26.4E	30.1E	31.1E	29.2E	24.3E	17.8E	9.8E	.9E	-8.8E
11/ 1	102.1A	113.4A	125.2A	138A	152.2A	167.5A	183.4A	199.2A	213.9A	227.5A	240A	251.6A	262.6A
	-9.5E	-.2E	8.2E	15.5E	20.8E	24.2E	25E	23.2E	18.7E	12.5E	4.7E	-4E	-13.5E
11/15	104.5A	115.5A	127A	137.5A	153A	167.6A	182.7A	197.8A	211.9A	225.1A	237.2A	248.6A	259.4A
	-12.9E	-3.7E	4.5E	11.6E	16.8E	20.1E	21E	19.3E	15.1E	9.1E	1.7E	-6.9E	-16.3E
12/ 1	105.7A	116.5A	127.8A	139.8A	152.9A	166.8A	181.4A	195.8A	209.6A	222.4A	234.4A	245.6A	256.2A
	-16.1E	-7.1E	1.1E	8.1E	13.3E	16.7E	17.7E	16.3E	12.5E	6.8E	-.3E	-8.7E	-17.8E
12/15	105.5A	116.2A	127.3A	139.1A	151.8A	165.5A	179.8A	194.1A	207.7A	220.5A	232.4A	243.5A	254.1A
	-18E	-9E	-.8E	6.2E	11.6E	15.1E	16.4E	15.2E	11.8E	6.4E	-.6E	-8.8E	-17.8E

your time right to the minute. Then apply the corrections. A nautical almanac and a good book on marine navigation can put you exactly on target. But it's hardly worth the effort in as much as a gentle jockying of the dish will put you on boresight in no time at all!

BONUS...PREDICTING SUN TRANSIT OUTAGE!

Perhaps you know by now from the literature that the sun gets **directly behind** each satellite about twice a year. The weak transmitter power of the satellite is no match for the sun and your receiver. To use a TV phrase, **takes black**! The signal will disappear for a period of time (dependent on many factors but mostly due to the beamwidth of your antenna). If you run a TV station or a Cable system, then solar outage can be better tolerated if you at least know when to expect it. To anyone else, it's good to know when your system may start to act up.

It's hard to know precisely when solar outages will happen unless you are an astronomer or know something about marine navigation tools. But wait. The sun will have the azimuth and elevation as the satellite at the time of an outage. Aha! If we know when the sun will have the same coordinates as the satellite, we can predict the exact moment of the outage.

All you need to do is scan the **STT Sun Shot Chart** for your latitude and note the time when the sun has about the same azimuth and elevation as the satellite. Easy isn't it?

FINE TUNING TECHNIQUES REVEALED

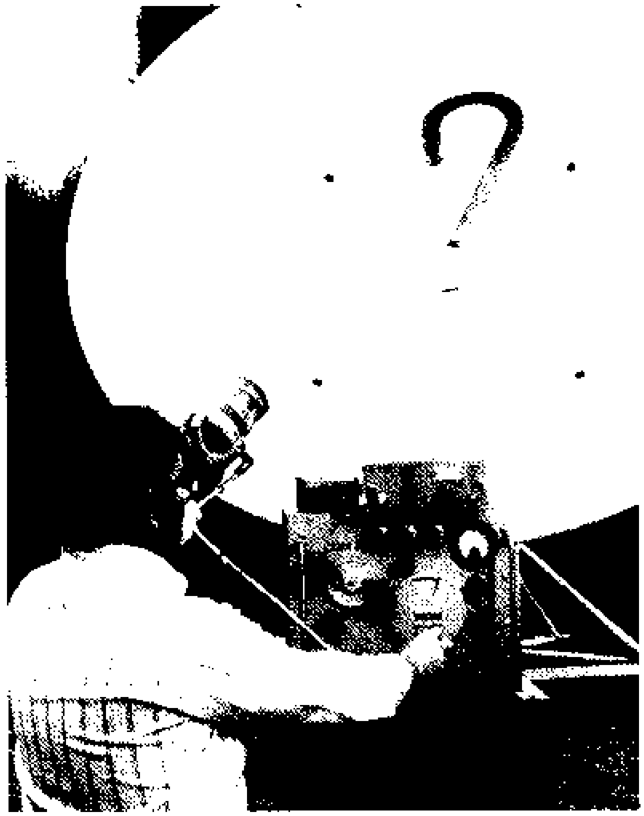
At this point, if your equipment is working properly and you are tuned to a working transponder, you should see some kind of a picture. I say 'should' because other variables are involved such as 'sun outage'. Of course you can verify that by simply looking at the shadow cast by your LNA feed point. Other problems you might have are that you may be tuned to a vertically polarized transponder while your antenna feed is horizontally polarized. The test for that possibility is simple enough, but you must remember to test one thing at a time. Too often you can fool yourself by changing parts or making more than two adjustments at a time. **This is clearly a no-no** because you can unknowingly cause something to stop working which now puts you in the very unhandy position of having more than one variable to control to get a picture.

Let's say you **know** the equipment is working and you **know** the dish is aimed as best as the accuracy of our simple instruments will permit. What then? Remembering that we must change only one thing at a time, we can gently sweep the dish a few degrees left and right of what we believe is the proper azimuth angle. **Small adjustments are safer** and while it will be very hard to contain your excitement, it is known from the experience of scores of antenna installers that you must go slowly to achieve rapid success.

If you still haven't received a picture, then you must restore the antenna to your best estimate of the azimuth angle and begin to adjust the elevation angle in small increments. **One adjustment at a time is the key.**

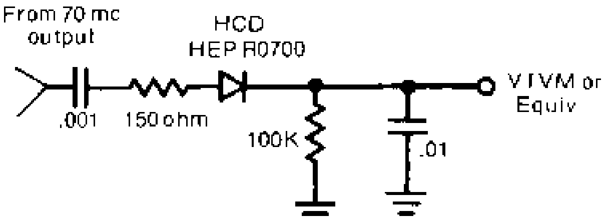
An alternative method is to **slightly** adjust the elevation and then re-sweep across the azimuth position. This practice is **repeated** for various elevation angles that are very near the calculated values. It is best to start at an elevation angle on one side of the predicted value and work your way through it each time gently sweeping the antenna a few degrees on both sides of the predicted azimuth values. You must be careful not to move the antenna in too large jumps in the elevation plane or you might miss the bird when you sweep the azimuth plane.

The measure of your ultimate success at this point will be totally up to your partner in this project... none other than Edsel Murphy. You may remember him as that fabled seer who said "**If anything can go wrong...it will**". Ridding your TVRO of Edsel Murphy's influence is the bane of all satellite pioneers. If he has graced your station with a visit, then it's time to adopt stronger measures.



SURPLUS model 616AL generator and a coffee can antenna makes a dandy satellite simulator.

TUNE-UP METER DETECTOR

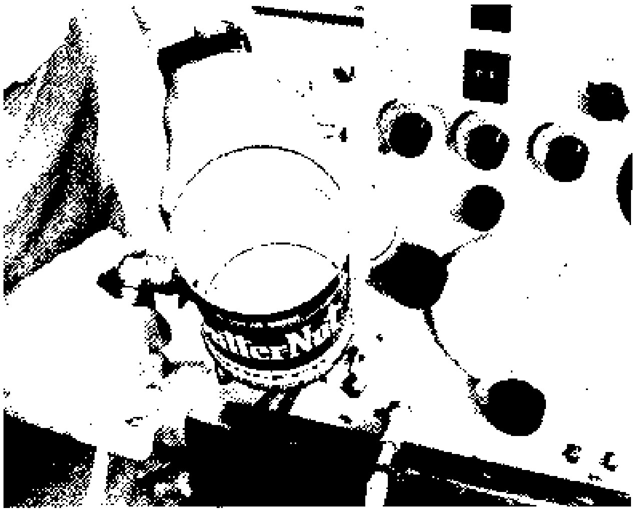


(Part of world's most expensive crystal set.)

FIGURE 24

It's best to start over by first checking your equipment for proper tuning and cable connections. An easy way to test your entire antenna/LNA/receiver set-up is to simulate a satellite signal by connecting the output of a microwave signal generator to a small antenna and pointing it at your dish. Coffee cans make dandy 'horn' antennas as seen here. The probe antenna is about 1 inch long and positioned on the end (center pin) of an 'N' connector located about 1 inch from the rear of the can. Your TV screen should **go black** as the generator falls within the lock-in range of your reciever.

Perhaps an easier test instrument is the 'Freebee Photon Source'...the sun. Just swing your antenna around and point it at the sun. A noticeable increase in noise should be seen **immediately** as you swing past the sun using the shadow cast by the LNA/feed point as a sight. You can use a diode detector and a meter (**figure 24**) tied to the output of your 70 MHz IF strip as an effective indicator and calling it perhaps the world's most expensive 'amplified crystal set' or at least one of the



WHILE BUTTER-NUT can works very well, who knows the output you might get from a Folger's or Maxwell House can!!!

world's cheapest solar radio telescopes! Take your pick. The key idea here is to see some kind of change in the noise level because of the sun. The more the better.

THIS NONSENSE HAS GOT TO STOP!

With your equipment thoroughly checked, you can return to the antenna pointing angles. Recheck your calculations for the location of the bird. Crazy as it sounds you can get your own coordinates wrong and thereby cause your answers to be screwy. **Check the obvious.** Recalculate the position of the bird. Double check yourself by using the satellite pointing charts. An error of more than a few degrees should be suspect.

Next study your antenna. Is the LNA **really at** the focal point? An error of an inch or more can mean zero signal into your receiver despite the fact the dish is 'right on' the bird. Either check with the manufacturer or **calculate the focal point** from this simple formula .

$$\text{focal point} = \frac{(\text{diameter})2}{16\ \text{X depth}}$$

Next recheck your elevation inclinometer. Is it resting on a surface that **really is 90 degrees** or tangent to the look angle of the dish? You can check it to within a degree or two by pointing your dish at the sun using the shadow method we described before and then seeing if the inclinometer agrees with the sun elevation angle for your location on this date from the **STT Sun Shot Charts**.

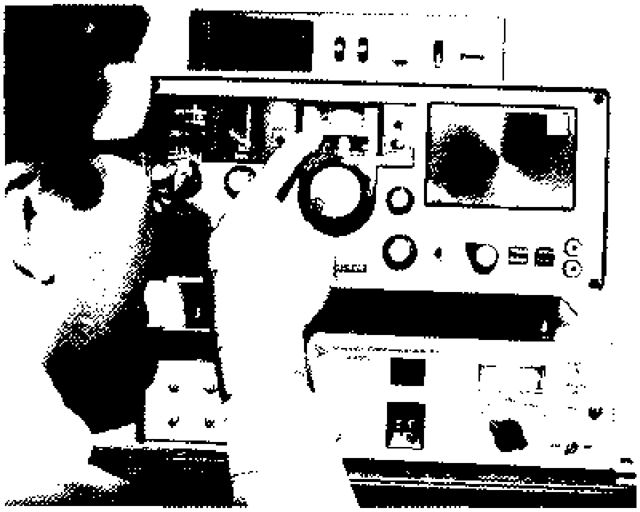
Lastly, recheck your azimuth angle. If you use the sun shooter method, then double check yourself with a compass. Just stand some distance away from the antenna with the compass oriented for true north (use the Generalized Magnetic Variation chart in **Appendix B**) and eye-ball the azimuth angle from you to the center line of the dish.

If you've checked your equipment and aligned your dish and still don't have a signal, it's a good idea to shoot for another satellite because you will more often than not discover your error while going through the routine again. The secret to antenna pointing is to reduce the number of variables. When you arrive at simple azimuth and elevation angles as the only possible variables left and you know for sure you've aimed your antenna right, then and only then can you say that the satellite is either dead or that somebody must have shot it down!

GETTING THE TIP OF THE PEAK

Once you've had that magic moment when your first picture climbs out of the sparklies you may almost immediately want to improve it. Rocking the antenna back and forth or up and down while looking at the picture works rather well. It works even better if you tune the receiver to **the weakest transponder** (the one with the **most** sparklies) and make your antenna fine adjustments.

An even better method for purists or those with marginal size antennas is to get a meter on the receiver. A simple method to use if you don't have a meter is to connect a shortwave radio that has an 'S' meter on it to the video output of your receiver and tune the radio to a data carrier on one of the many data transponders (tune 0 kHz to 4 MHz). Some receivers have filters ahead of the video output to effectively screen out the sound carriers above 5.5 MHz. It is not too difficult to simply open up the receiver with the diagram in hand and tap-into the circuit just ahead of the video lowpass filter. In fact a new connector installed on the back of your receiver and a line running from it to this tap-into point is a worthy addition so that you can do some FM music or data subcarrier hunting at a later time.



A SHORTWAVE RECEIVER makes a dandy tuning meter. The receiver allows tuning in transponder carriers and monitoring them with the 'S' meter long before they are strong enough to register on TVRO receiver meter [below].

Okay, you've connected the radio and discovered you can almost understand FM sound on an AM receiver if you tune it right. **Instead**, tune for an **unmodulated carrier** rather than FM (there are hundreds between 500 kHz and 3 to 4 MHz on non-video transponders). Now look at the 'S' meter on the radio. That's your indicator. If it's 'pegged' at the top, you must turn down the shortwave receiver RF gain or install a resistive pad to cut the signal into the receiver to the point that you get a convenient reading. Sometimes when Edsel Murphy is not around you can discover that the nifty video carrier lowpass filter the manufacturer installed is just enough pad to attenuate the signal and you simply connect the receiver to the video output!

Now it is a simple matter to rock the antenna and watch the 'S' meter as an indicator. If you don't have a shortwave receiver but still want a meter, then build the super simple crystal set in figure 24 and tie it to the 70 MHz IF output. If you tie the crystal set to 741 IC opamp wired as a DC amp, you can run a line out to your antenna as an outboard 'S' meter and see first hand what happens when you change position.

BUILDING THE MOTORIZED MOUNT

A lazy Sunday of satellite hopping has either got to be a symbol of weirdness in the 80's or the absolute proof that you've got what it takes to reach for and attain the benefits from what many think is a wild odyssey. Just imagine yourself with more than 68 channels at your fingertips. Push a button and your antenna moves from satellite to satellite, as though it were hopping from universe to universe. 68 channels and

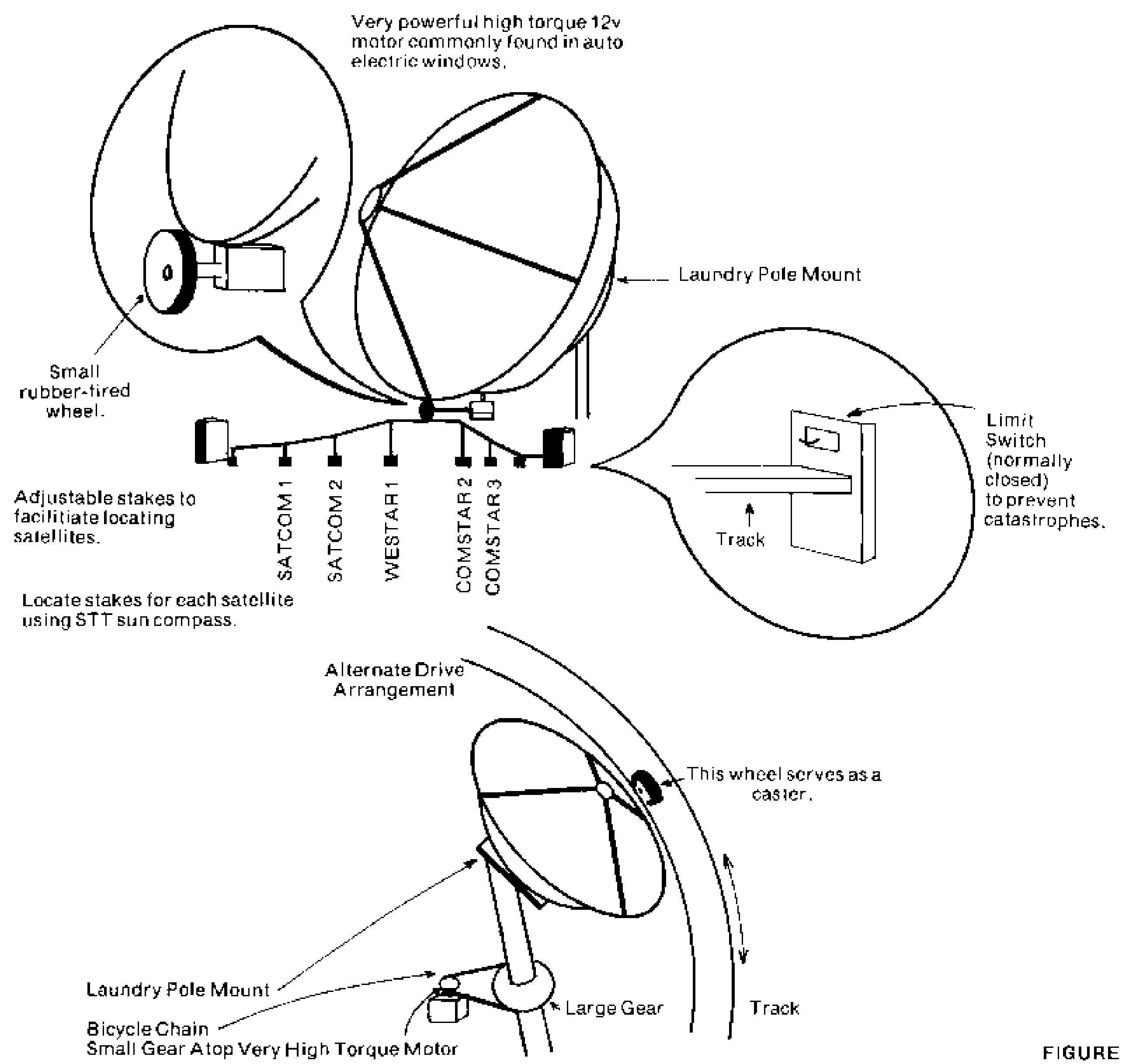

Very powerful high torque 12v motor commonly found in auto electric windows.
Laundry Pole Mount
Small rubber-tired wheel.
Limit Switch (normally closed) to prevent catastrophes.
Track
Adjustable stakes to facilitiate locating satellites.
SATCOM 1
SATCOM 2
WESTAR 1
COMSTAR 2
COMSTAR 3
Locate stakes for each satellite using STT sun compass.
Alternate Drive Arrangement
This wheel serves as a caster.
Laundry Pole Mount
Bicycle Chain
Small Gear Atop Very High Torque Motor
Large Gear
Track

FIGURE 25

growing! And that's just the pictures. By now you know that there is more than just pictures up there. Wait till you hear the stereo music! And how about tying into that 'great database in the sky'? But we digress. So let's swing back on track and figure a cheap way to realize that lazy Sunday of satellite hopping.

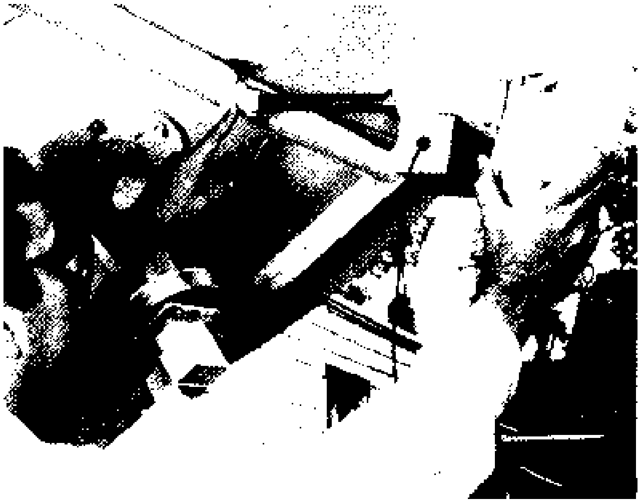
Hanging a motor or two on a mount is really a custom job, but we can still suggest a few techniques that may steer you (no pun) in the right direction to quick, success. Keep in mind now that you don't have to know how an LNA works or any other technical stuff to motorize your mount. It's about as easy as installing an electrical socket if you can get a strong enough motor and some sturdy hardware to mount it. Levers, gears and chain drive connection arrangements are a piece of cake once you know how they work. We'll touch on the details as we go.

If you've installed a polar mount and only intend to reach a few satellites, then you may only need a single motor which you would mount on the single turning axis. You may choose to use a manual 'trailer jack' to adjust the declination in as much as you may not need to reach all the satellites in view at a time. On the other hand, two motors will give you worthwhile unlimited control. The AZ/EL mount will require two motors. Believe it or not, installing two motors is not twice as hard as installing one as we shall soon see.

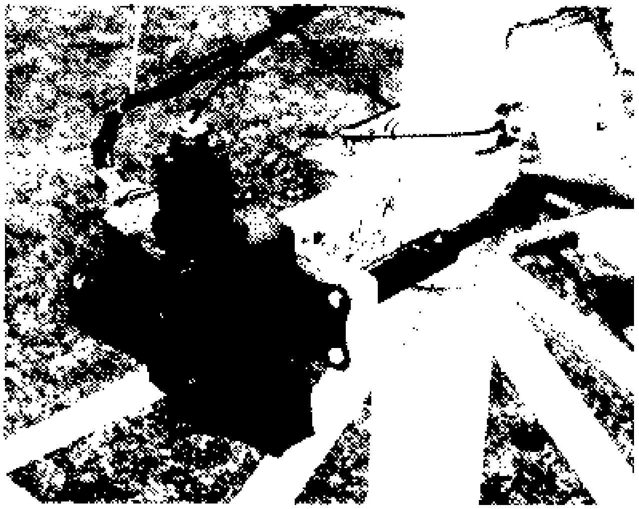
Before we get more into the hardware, this might be a good place to suggest a special case where you actually could use only **one motor** and hit every bird. First you build the 'Laundry Pole' mount and stick a motor on the base of the dish as seen in **figure 25**. The motor has a gear on it and enough electrical wire to let it run along a curved track around the base. The height of the track is adjustable so the elevation of each satellite can be precisely set. But the motor and the track do not necessarily have to be geared. You could use a wire or winch approach so the motor would pull the dish along the track. Of course the motor must be reversible so you can swing the antenna in either direction. Another variation would be to simply lock the bottom of the dish in the track with something as simple as a wheel from a child's wagon and then apply a chain drive motor to turn the entire base. This idea is pure speculation and needs some hard thinking before it can be made to work.

By the way, Swan antenna builders might find this track idea is just the ticket for mounting your feedpoint on a movable mount so you too can change satellites using only one LNA!

Another style of motor is the linear actuator. What's that? It's only a motorized shaft that moves in and out of a pipe. Dandy for moving dishes and cheap. A surplus linear actuator (Model 3870R) with a throw of nearly 6 inches runs about $37.50 from **Airborne Sales, 8501 Steller Dr., Culver City, California.** Photos show you how a linear actuator can be applied to adjust azimuth as well as elevation in the fine tradition of Robert Coleman's inexpensive techniques.



SURPLUS linear actuator bolts right to the dish.



ACTUATOR BOLTS to a hinge mounted on the azimuth pole. Adjusting the distance from the center of the pole controls the number of degrees of rotation. NOTE: This......

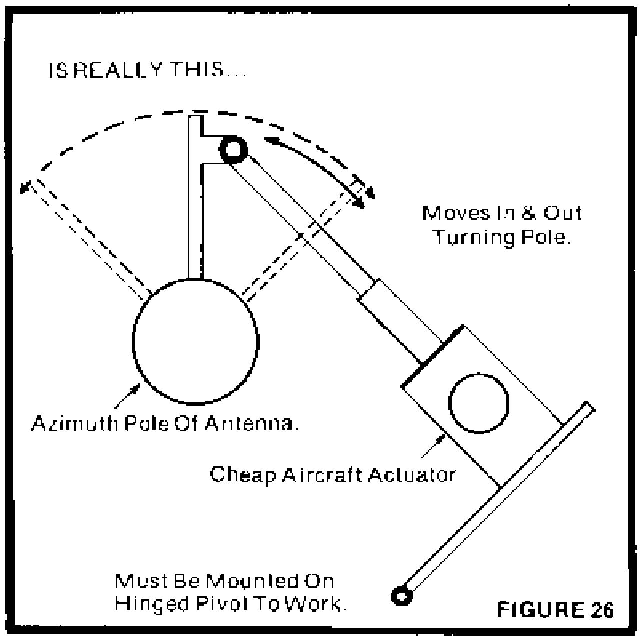

IS REALLY THIS...
Moves In & Out Turning Pole.
Azimuth Pole Of Antenna.
Cheap Aircraft Actuator
Must Be Mounted On Hinged Pivot To Work.

FIGURE 26

Suppose you need more of a throw than 6 inches? You can use simple levers you build from parts found at the hardware store or the junk yard. Looking at the diagram in **figure 27**, you can double the throw of any moving rod by connecting it to this simple lever arrangement, sometimes called a bell crank. The distance lever 'B' moves (your cheapy actuator) is doubled because lever 'A' (connected to your antenna) is twice as far from the turning point or fulcrum. Figuring the distances and dimensions is as easy as simple proportion arithmetic.

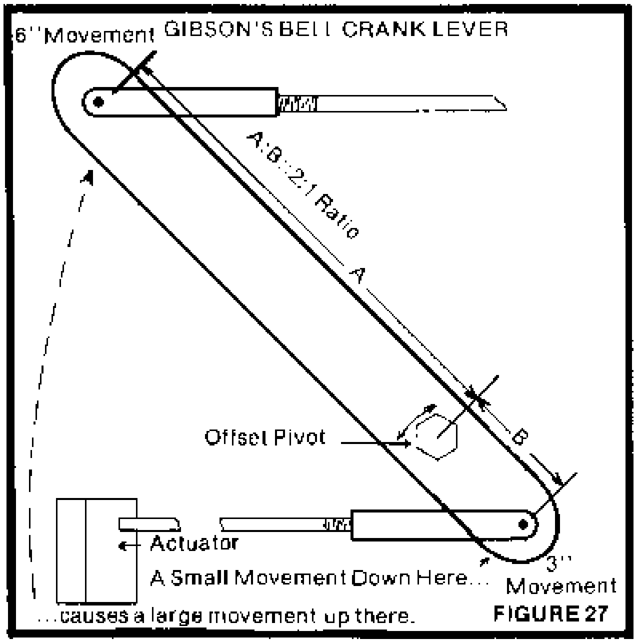

6'' Movement
GIBSON'S BELL CRANK LEVER
A:B::2:1 Ratio
A
B
Offset Pivot
Actuator
A Small Movement Down Here...
3'' Movement
...causes a large movement up there.

FIGURE 27

Another simple method of moving your antenna is to use a screw jack. You can build a unit like the one in **figure 28** by mounting a long pipe on the end of a motor that turns rather slowly (less than a few hundred RPM). A single nut is welded on the end of the pipe. Then a long threaded rod is screwed a few turns into the nut. The other end of the rod is connected to the dish. As the motor turns, so does the pipe which causes the threaded rod to be screwed deeper into the pipe and pulling your antenna around on it's axis.

You can find a good motor bargain from time to time in the catalog of **Herbach and Rademan Inc., 401 E. Erie Ave., Philadelphia, PA 19134**, or the catalog from **C & H Sales, 2176 E. Colorado Blvd., Pasadena, California 91107.**

Both the motor and the rod must turn on their mounts. A large door hinge is a simple solution to this problem. Perhaps the key point here is to first understand what you want to do and then look around for what is available to do it. A trip to a junk yard to just browse is what we mean. Rather than recommend specific components, it is better for you to see what's handy and use it.

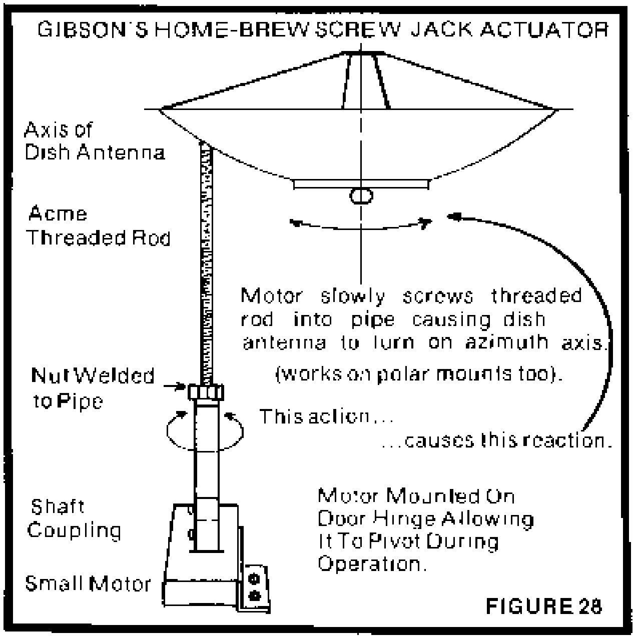
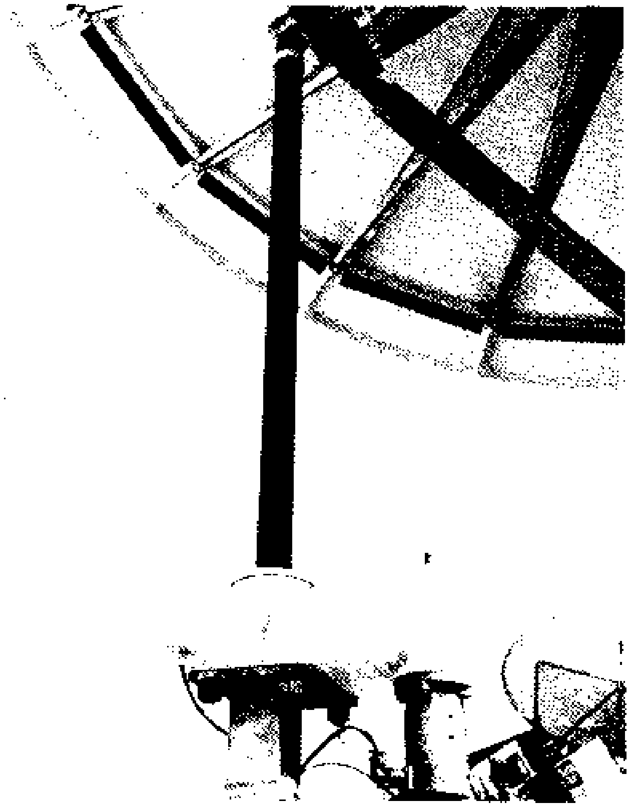
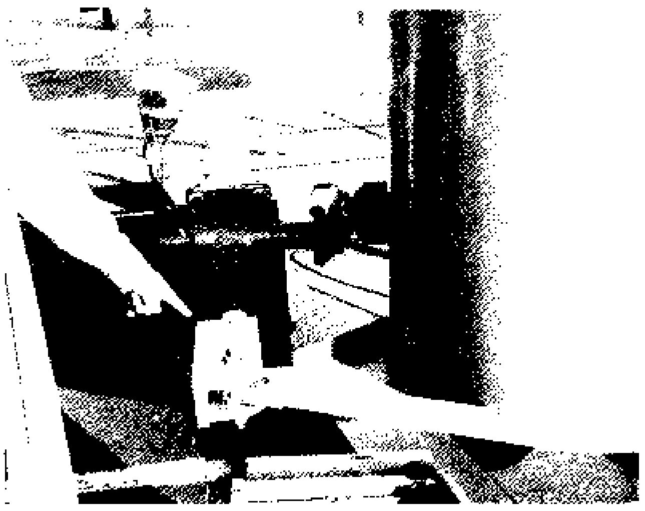

GIBSON'S HOME-BREW SCREW JACK ACTUATOR
Axis of Dish Antenna
Acme Threaded Rod
Motor slowly screws threaded rod into pipe causing dish antenna to turn on azimuth axis.
(works on polar mounts too).
Nut Welded to Pipe
This action...
...causes this reaction.
Shaft Coupling
Motor Mounted On Door Hinge Allowing It To Pivot During Operation.
Small Motor

FIGURE 28



SCREW JACK in use as a polar mount.

While a belt drive may seem attractive in as much as automobile fan belts are readily available, it's not a good idea because a stiff wind may cause your antenna to slip off the satellite. **We need solid rigidity.** Backlash or slop in the method you use to interface the motor could easily make you feel your antenna was back on that shakey saw horse! Doing it the easy way may not necessarily be the most satisfying later on. Still, one easy method to interface the motor is to use a simple bicycle chain drive. We must be careful here to watch for backlash or slop. **An adjustable mount** for the motor to remove slack in the chain is an absolute necessity.



HORIZONTAL screw jack used for azimuth axis.

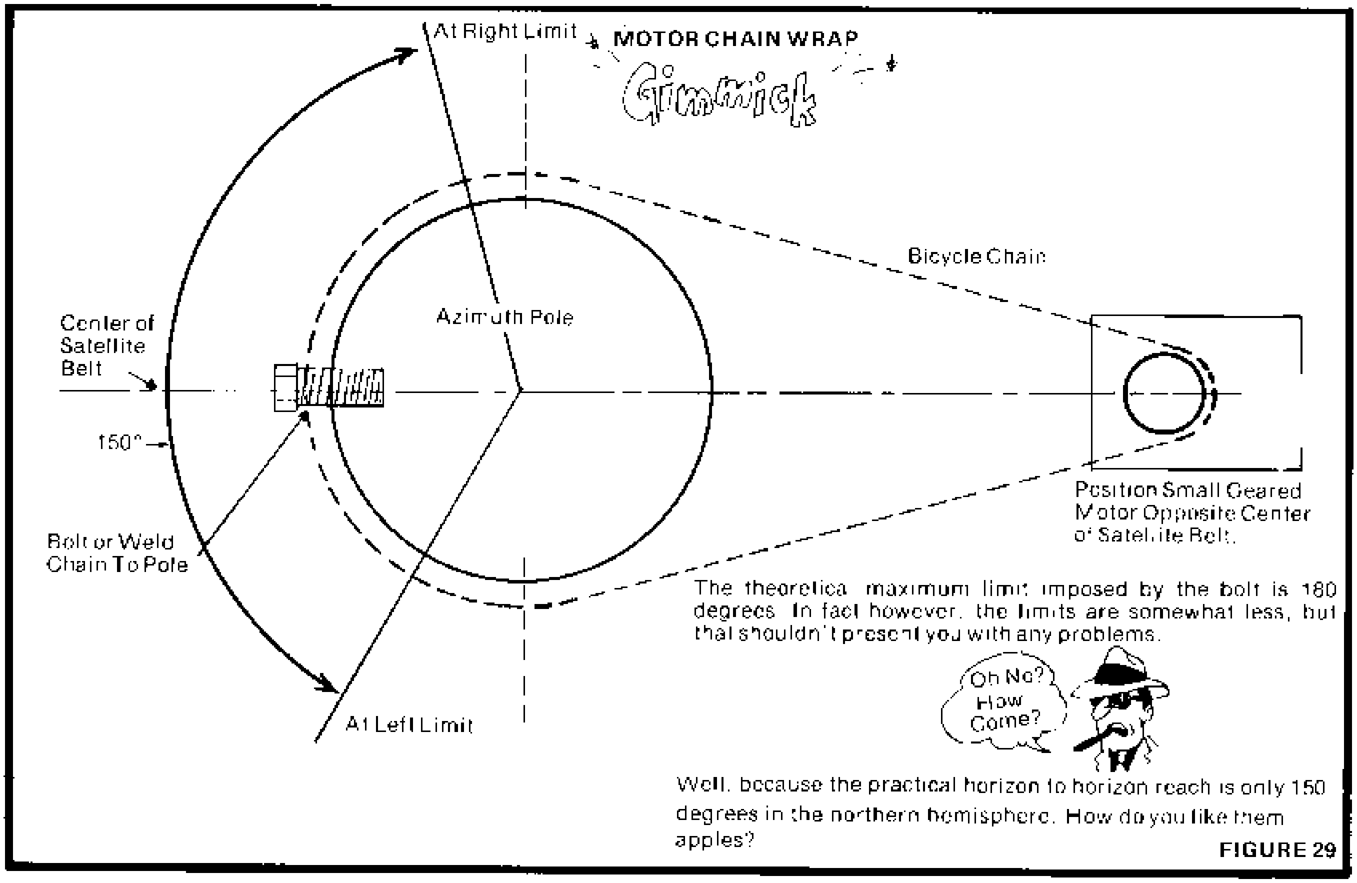
The secret, if any, to making sprockets and chains work for you is to know something about ratios. When a small gear makes a turn, it causes a larger connecting gear to make less than a turn. The possible arrangements available to you are endless and you can calculate what you may need from simple formulas found in any complete gear catalog. One popular gear company is Boston Gear and you can obtain their thick catalog by writing **Boston Gear, 14 Hayward St., Quincy, Mass. 02171.** They have branch offices in other major cities which would be only too happy to supply you with more info on gears, chains and sprockets than you can digest in a week!

Installing a chain drive arrangement is a piece of cake. Bicycle chain is easy to find and a small sprocket slipped onto the shaft of your motor is all you really need. In fact, you can do it all with a single sprocket! The idea here is that you wrap the chain around the turning axis of the antenna and secure it as seen in **figure 29**. The motor moves the chain and the antenna will still turn, but only one sprocket is needed. All you have to do to make this neat trick work is to use care in the positioning of your motor.

POWER SUPPLIES AND CONTROLS

The kind of controller you build will largely depend on the type of motors you install. You may need only a few switches and some extension cords if you install AC motors. But a high current power supply will be necessary if you use DC motors. While this may at first sound like a good reason to avoid DC and use AC, we should remember to use whatever may be at hand or a good bargain. For instance, an automobile electric window motor has terrific torque and junk yards sell them. The military surplus market is loaded with DC motor bargains.

The high current supply can be as simple as a car or motorcycle battery or more complex with interlocking limit switches to keep your antenna from turning too far. In fact, the interlocking limit switches are a good idea no matter what you choose to use in the AC or DC department.



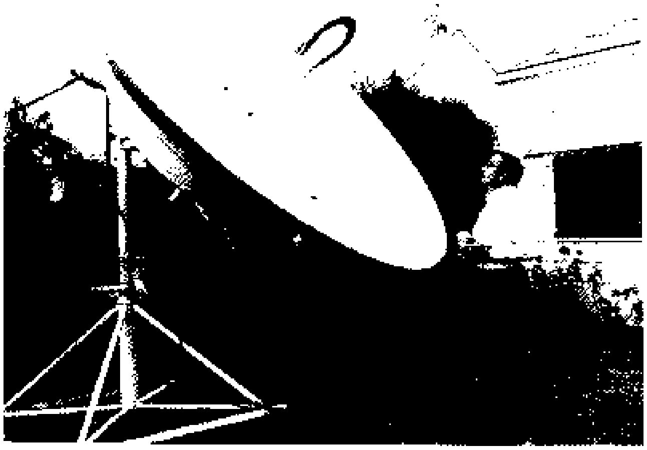
The theoretical maximum limit imposed by the bolt is 180 degrees. In fact however, the limits are somewhat less, but that shouldn't present you with any problems.

Well, because the practical horizon to horizon reach is only 150 degrees in the northern hemisphere. How do you like them apples?

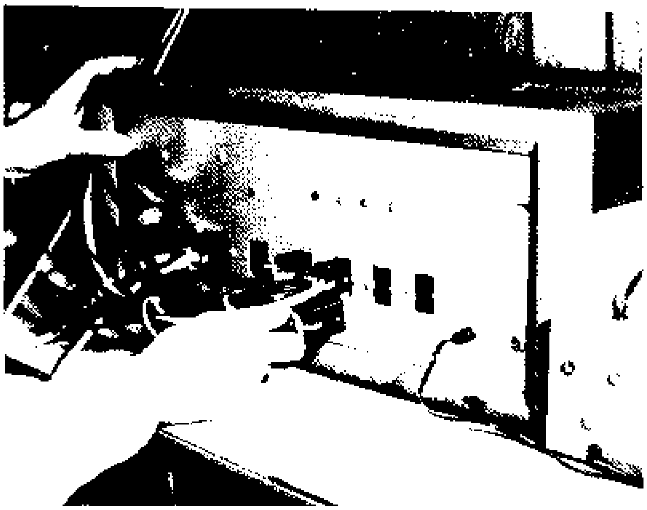
FIGURE 29

Switching the motors on and off can be done with solid state controllers or simple relays. Keeping it simple has it's advantages. We must use some kind of indirect control in as much as switching 20 amps of motor current from over 200 feet away at your TV set is not too practical. Locating the supply or battery nearby and using low voltage relay controls is an easy way to give you that 'armchair' control we were talking about. The circuit diagram in **figure 30** uses such an approach so that the control box can be plugged in at the dish for testing as well.

Interlock contracts to the motors in **figure 32** are used in the circuit to obviate a catastrophe. The relays are simply cheapy 12 volt Guardian DPDT wired in parallel. They are fed 15 volts however to compensate for voltage drop all the way back to the TV. A remote button closure grounds the other end of the relay connected through the limit contacts at the motors or actuators. The exact arrangement of the relay controls may very well depend on the motors you use, but the relay coil



LOCAL CONTROL BOX duplicates the functions found at the 'Armchair' and computer.



CONTROLLER IS MOUNTED in an old equipment case located near the antenna in garage. Jones plugs feed power to the motors over household lamp cord to drop motor voltage so dish moves at something less than Warp Factor 4. Small box at right is protected LNA supply.

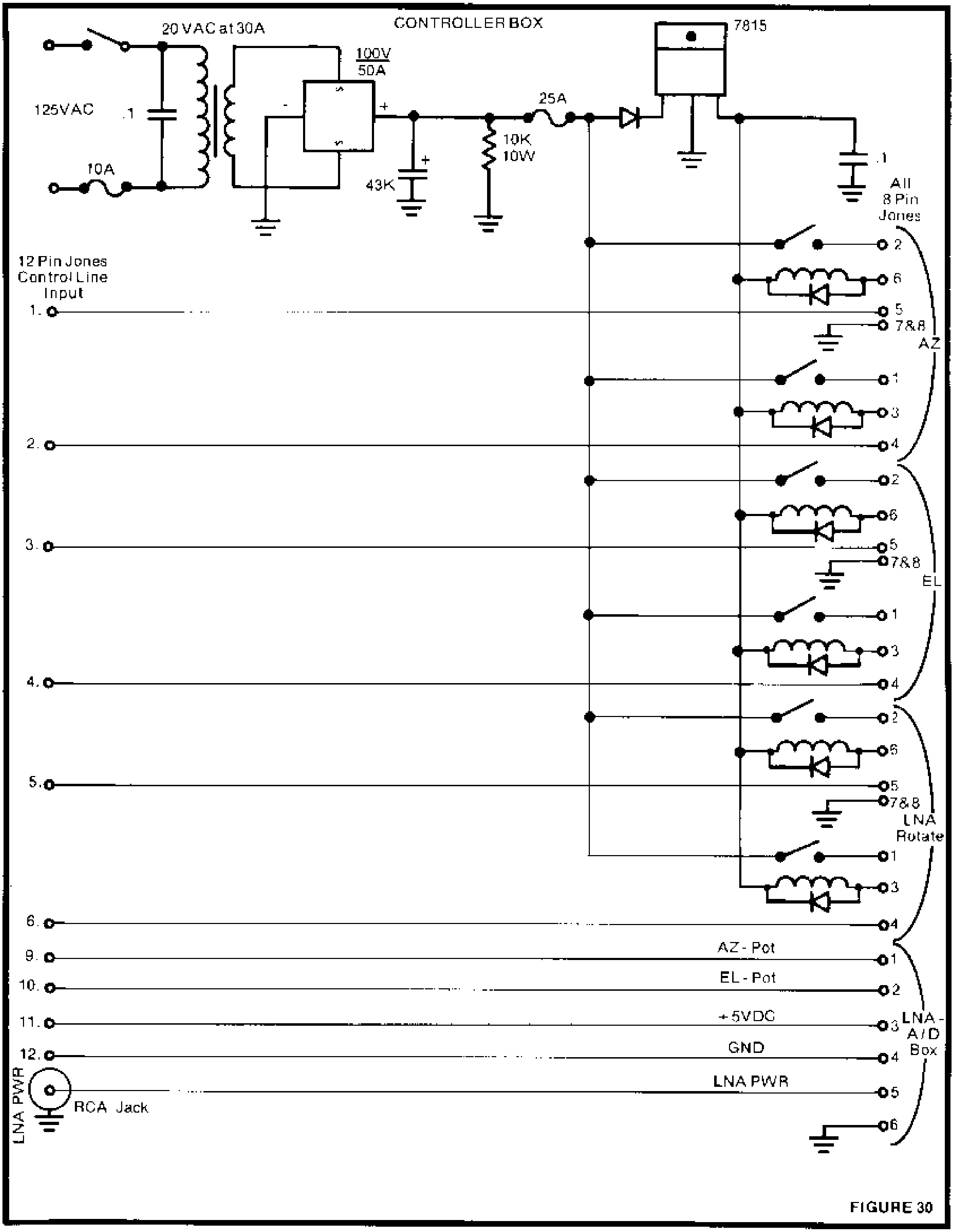

CONTROLLER BOX
20 VAC at 30A
125VAC
.1
10A
100V
50A
-
+
43K
10K
10W
25A
7815
.1
All
8 Pin
Jones
12 Pin Jones
Control Line
Input
1.
2.
3.
4.
5.
6.
9.
10.
11.
12.
2
6
5
7&8
AZ
1
3
4
2
6
5
7&8
EL
1
3
4
2
6
5
7&8
LNA
Rotate
1
3
4
AZ - Pot
EL - Pot
+5VDC
GND
LNA PWR
1
2
3
4
5
6
LNA -
A/D
Box
LNA PWR
RCA Jack

FIGURE 30

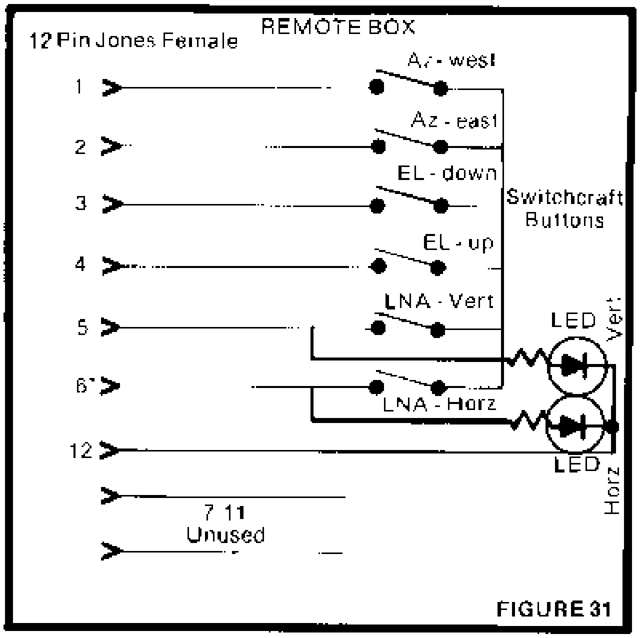


FIGURE 31

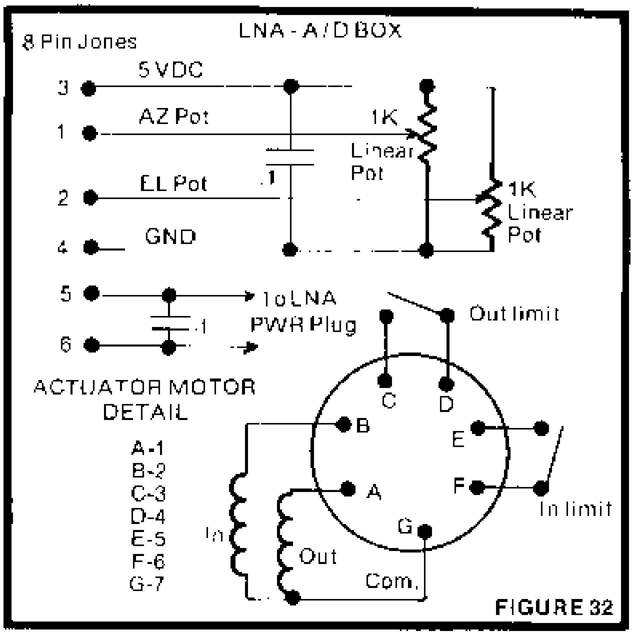
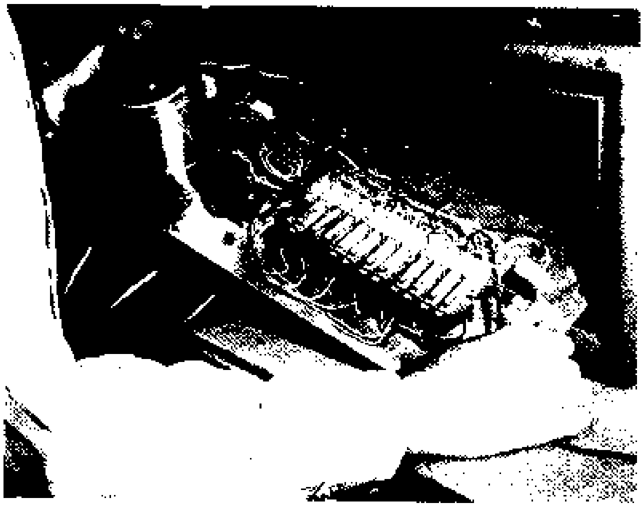


FIGURE 32

circuits used here are particularly useful for later expansion to computer control as we shall soon see.

The supply should be mounted as close to the dish as possible. In my installation where the linear actuators were used, the 26 volts DC made the actuators move too fast. Supplying their voltage **through household lamp cord** provided a convenient voltage drop. All the relays and associated hardware were mounted on a rack panel and bolted into an old equipment enclosure. 8 pin Jones plugs were used for each actuator (Az El and polarization).



MOUNTED on a 19 inch rack panel, Guardian relays control the dish drive motors.

The feed from the house is a 12 pair #22 cable also terminated in a Jones plug (I got a lot of 'em in my junk box). While the entire interface could have been operated on a single pair by the clever use of UARTS or the nifty BSR Remote Command Units sold by Sears, I totally agree with the wisdom of Taylor Howard that "...there are better ways to do each and every circuit here, but life is too short..." and besides, I already had 200 feet of 12 pair cable!

The remote control box in **figure 31** can also be plugged in at the antenna for adjustments by a second Jones plug that simply parallels the first. LED's steal current from the relays as polarization indicators. The computer interface and LNA power also feed through the controller box

KNOWING WHICH WAY YOU'RE POINTED

Without a doubt, motorizing your mount is a giant step to the ultimate convenience of true armchair antenna control. The only problem is that you must always be checking your inclinometer and/or azimuth to see if you are near the satellite you want. Then you must swing back and forth on both planes using some of the methods we've described to lock on the bird. There must be a better way!!

Enter the position feedback control...a way to see where the antenna is pointed at any given instant. Naturally the accuracy of your ability to find a point in the sky will be only as good as your indicator. So you must be reasonably careful of what you do and how you do it. Two methods are open to you. The digital method and the analog method. Both as you may have guessed have their advantage and drawbacks.

For most people, the digital method is more complex to understand (much less build) so let's hit on it quickly for those that may want to use it and then move on to the more simpler analog method and steps we must take to make it almost as good as the digital method. Why is the digital method more accurate? Most of that question might be answered by saying that the accuracy of any reading we get will be affected by the way we design the interface. Reading an LED or LCD display of decimal numbers may be more accurate than a meter, but that's not the reason. That's the readout. The ability to split hairs is a better way to say it. **Remember** - our goal is to find a **single spot** in the sky with better than a degree of accuracy.

So the actual device that does the translation of telling the readout where your antenna is pointed has got to be the key. In digital form it can be a bar code strip like you find printed on just about anything you buy nowadays at the supermarket. The bar code strip can actually be a long strip that might be pasted on the center azimuth pole of your mount (**figure 33**). An optical light pen would then read the bars as the pole turns. When the pen sees a bar, it outputs a logic 1 or a plus voltage which may for many light pens be roughly 5 volts DC. When no bar or a space is seen by the light pen, it outputs a logic 0 or something like zero volts DC. The output can be either 5 volts or 0 volts depending on what the light pen sees at any instant. Turning your antenna would cause the light pen to see alternating bars and spaces. The readout is a stream of bits or to be more specific a kind of square wave whose frequency is wholly dependent on the speed of rotation.

DIGITAL DISH POSITION INDICATOR

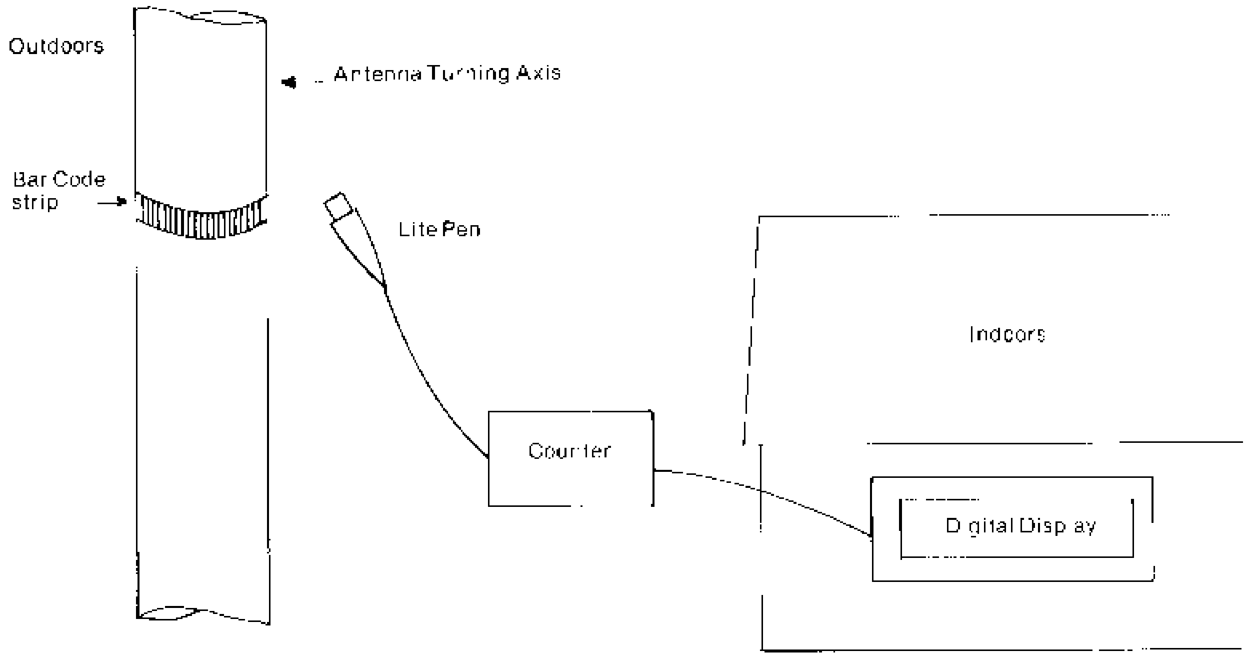
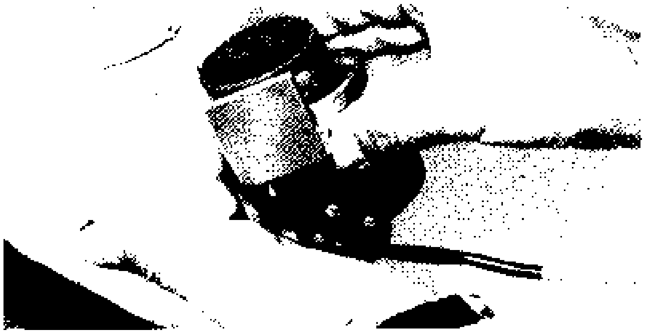


FIGURE 33

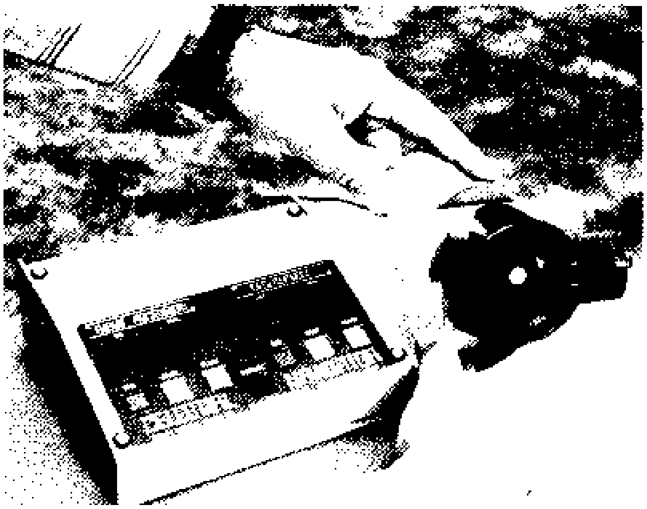
How do you turn that into numbers we can understand? A frequency counter wouldn't work because it would only tell you the speed of rotation and we don't need to know that. However another kind of counter would work. An event counter. Suppose we just count the number of bits that go by the light pen as the antenna turns. If the bits were positioned at one degree intervals, then we would get an output bit or pulse or count every time a bar went by. Neat huh? We could even use one of those cheapy counter modules you may have seen at Radio Shack as a readout.

The idea won't work though because we could only go in one direction and stop. We could never **go back** because the light pen would only record changes **or events** and the counter would continue counting **up and up** while it should be going down! Several possibilities exist for overcoming this problem. One simple solution is to install a second bar code strip slightly staggered from the first and use a second light pen setup to read it. The output from the second light pen would be different in time from that of the first if your antenna rotation were to change direction. This difference could signal the counter to go up or down.

Still another problem exists for the digital shaft encoder as it is called. If you lose power to the circuit, you also lose the known position of the antenna. The circuit forgets. True, you could devise a way to reset a digital display once power is restored or you could move the antenna back to the beginning point and start over. The technique is called indexing and is one of digital's great drawbacks. A very good circuit to



A FRICTION DRIVE optical encoder feeds the Tuthill telescope digital readout. Note the two small optical transducers against the stripe wheel.



THE TUTHILL ENCODERS work very well for an evenings telescope viewing but the friction feed must be replaced for more exact satellite readings.

accomplish digital feedback appeared in **Sky and Telescope** for August 1977.

If the idea of an optical coupled position readout sounds good, but you want a finished unit rather than building one, you might try a unit built for amateur telescopes sold by **Roger Tuthill, Inc., Box 1086, 11 Tanglewood Lane, Mountainside, NJ 07092**. Pictured here is a unit you program to read position from twin optical encoders. While the unit works very well on telescopes, a more direct coupling is needed for long term stability of readings. In fact, solving the power supply and solid coupling problem would make this unit just about the best method though not the cheapest you could employ.

CONNECTING A POT TO A DISH

If you can stand to see your accuracy of position drop somewhat then you might consider the very simple idea of connecting a movable potentiometer or rheostat to the **turning axis** of your antenna. The changing resistance of the pot as the antenna turns can change voltage or frequency readouts.

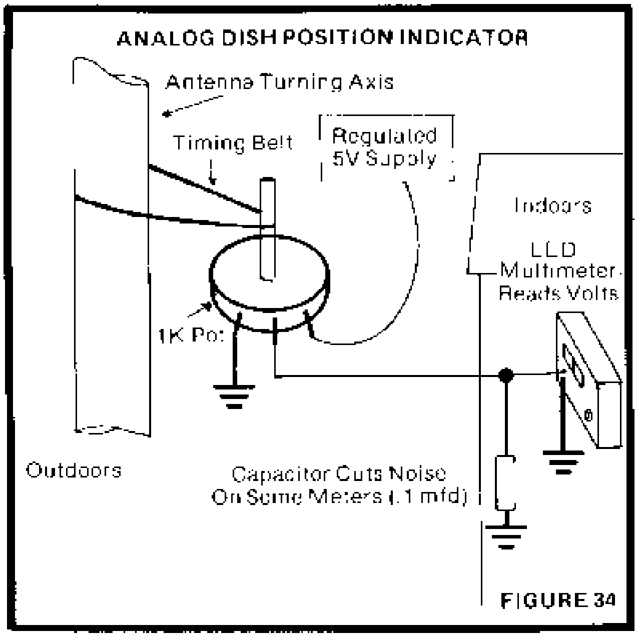

ANALOG DISH POSITION INDICATOR
Antenna Turning Axis
Timing Belt
Regulated 5V Supply
Indoors
LED Multimeter Reads Volts
1K Pot
Outdoors
Capacitor Cuts Noise On Some Meters (.1 mfd)

FIGURE 34

To attempt to boost the accuracy back up to a respectable level, a multi turn pot should be used. It should also have good linearity. No log or audio taper units. Crazy as it sounds, the resistance of cheapy pots does not change evenly as you twist from one end to the other. In fact, a computer test arrangement will reveal that it can look like the ragged edge of a long mountain range as the resistance changes. Good precision pots are not cheap. You can buy them surplus to save a few dollars. A very good source of precision linear pots that sell below $10 is **Beckman Instruments, 2500 Harbor Blvd., Fullerton, CA 92634**. Their model 7286 1K 10 turn pots might be what you want.

THE 555 STRIKES AGAIN!

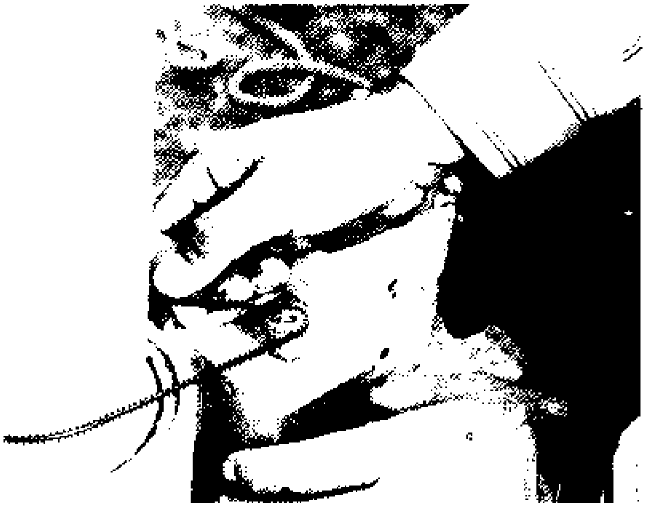
An easy way to read pot position is to use the popular 555 IC timer as an oscillator. The pot can change the frequency which you read with a frequency counter or use another 555 to integrate and read a voltage. Later on, you might want to tie your 555 into a computer as a one-shot whose pulse duration is very carefully timed by the computer in a counter loop.

The only problem will be getting enough resistance change to cause a large change in frequency. We are back to the problem of pot linearity. Precision pots you find on the surplus market are more than likely in the 1k to 10k range. The simple voltage readout begins to look better all the time.

How many turns are necessary? Much of the answer depends on the way you connect the pot to the antenna. Without going into connecting methods yet, we should say here that the maximum number of degrees of rotation your antenna will turn should equal the maximum number of degrees the pot can turn. Saying it another way, **you should use all of the resistance in the pot to achieve maximum accuracy**. So the pot will be at one end of it's slider when your antenna is at the limits of one axis and the pot will turn to the end of it's rotation just about the time your antenna arrives at the end of its swing.

The advantage of a multi-turn pot is that a it spreads out the resistance scale we want to read and it will also interface easier to the antenna. The key point to remember here is to be sure that **all** the pot is used. If your connection arrangement will only cause a rotation of perhaps 3 turns, then find a 3 turn pot or change the ratio to a value that fits the pot you have.

How you connect the pot to your antenna is really dependent on the way your mount is built. We can however suggest two very good methods. You will either need to translate linear motion to rotation or rotation to rotation. Actually, other methods do exist, but these methods are easy to try because the hardware is readily available.



A SMALL TIMING belt and gear from PIC Design interfaces a surplus linear pot to the antenna.

Rotation to rotation is simply connecting the pot through a gear or belt or chain to the antenna. You can install the pot in a minibox on the fixed part of the mount and connect a system of gears or try an easier way by installing a gear belt. The antenna rotation will cause the pot to turn. The size of the gears will govern the number of turns your pot will turn. We can save again as we did with the motors on the mount by carefully locating the pot at a point opposite the center position of the turning axis. In a photo we see how to accomplish this positioning so that a single gear is all that is required. This clever technique only works if the rotation is less than 180 degrees because the length of the gear belt would then be required to change. Lucky for us, we only need to change the position of our antenna 150 degrees or so on the azimuth plane (in North America) and even less on the elevation plane.

A very good source of small gears for pots is **PIC Design** at **6842 Van Nuys Blvd., Van Nuys, CA 91405**. They sell a large selection of belts, pulleys and chains. Their catalog is a complete technical reference on gear and gear belt design.

Linear motion to rotation is very similar to rotation to rotation. A rod or any movable axis attached to the antenna becomes the axis of linear motion and we simply connect something like a small timing belt to that point and wrap it around a gear that has been installed on a pot. We can return the belt to the turning axis with some difficulty or we can simply let it continue on as a linear motion and tie a weight to it so that the force of gravity will keep it taut.

GRAVITY FEED converts linear motion to rotation for the elevation pot interface. The timing belt is connected to the dish with a hose clamp.

While it may seem a good idea to simply tie the shaft of the pot to your motor shaft arrangement, the best advice is don't do it! Besides the obvious problem of gearing down to the pot, you have the problem of slop in your motor arrangement being added to the pot position as error. We've got to reduce error and backlash. No matter which way your antenna turns, the pot must instantly respond with a corresponding change. Failure to work this kink out of your interface may cause a lot of grief later.

MICROS DO IT BETTER

The ultimate control for your antenna system has got to be a computer. Until recently, the very idea of owning a computer let alone using one for a specific purpose was too expensive and not at all practical. Then along came the microprocessor and Radio Shack hot on it's heels to change all that.

While many may like the idea of a dedicated processor to steer the dish, the advantages of using a general purpose computer instead are great. The general purpose computer is more cost effective because you won't be scanning the skys all the time and therefore you can put the machine to work on other fun tasks such as balancing the checkbook or designing your own style parabolic antenna or better yet, decoding some of the News data feeds on various transponders. The 'Big Data Base in the Sky' is there. The Apple, Pet or Radio Shack (TRS-80) computers will do these jobs and more at a very reasonable price.

As you may have discovered, just about anyone can learn to program or even build a computer. It's all in the way you attack the project. For many, the idea of trading hardware problems for software solutions is hard to accept. The notion that you can cut the wiring to a minimum with a piece of software has got to be proven to the doubting Thomas types.

In it's most simple form, the computer gathers information from the outside world and, depending on the decisions made by the program, sends commands back out to control mechanisms connected to the interface. The secret to making such a simple arrangement work is in the software and the interface.

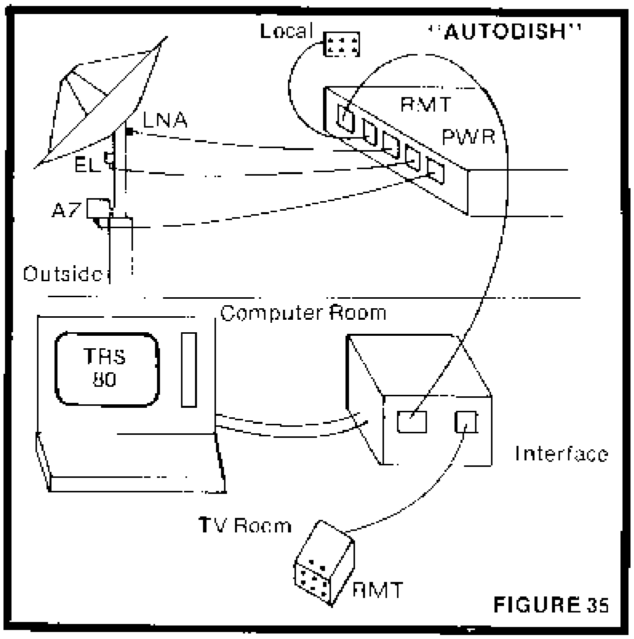


FIGURE 35

The specific application here is to move the antenna on command to any satellite that can be received by simply controlling the relays that drive the steering motors. The program sees where the dish is at any instant by reading the position readout pots with an analog to digital converter chip. Based on that information, the program issues commands to the motors to move in whatever direction is necessary to find the satellite.

PAINLESS INTERFACING

Lots of things botch up a computer interface to the outside world. Giving misinformation to the computer and forgetting to leave yourself a human override loophole rate pretty high. The interface design here seeks to overcome these problems by first of all operating independent of the manual control box. We just hang the interface on the lines.

Beating the misinformation problem is harder. The kinds of annoyances we had with readouts and the like are magnified to the tune of an orchestra we can't even hear because little subtleties we can't actually see let alone differentiate may

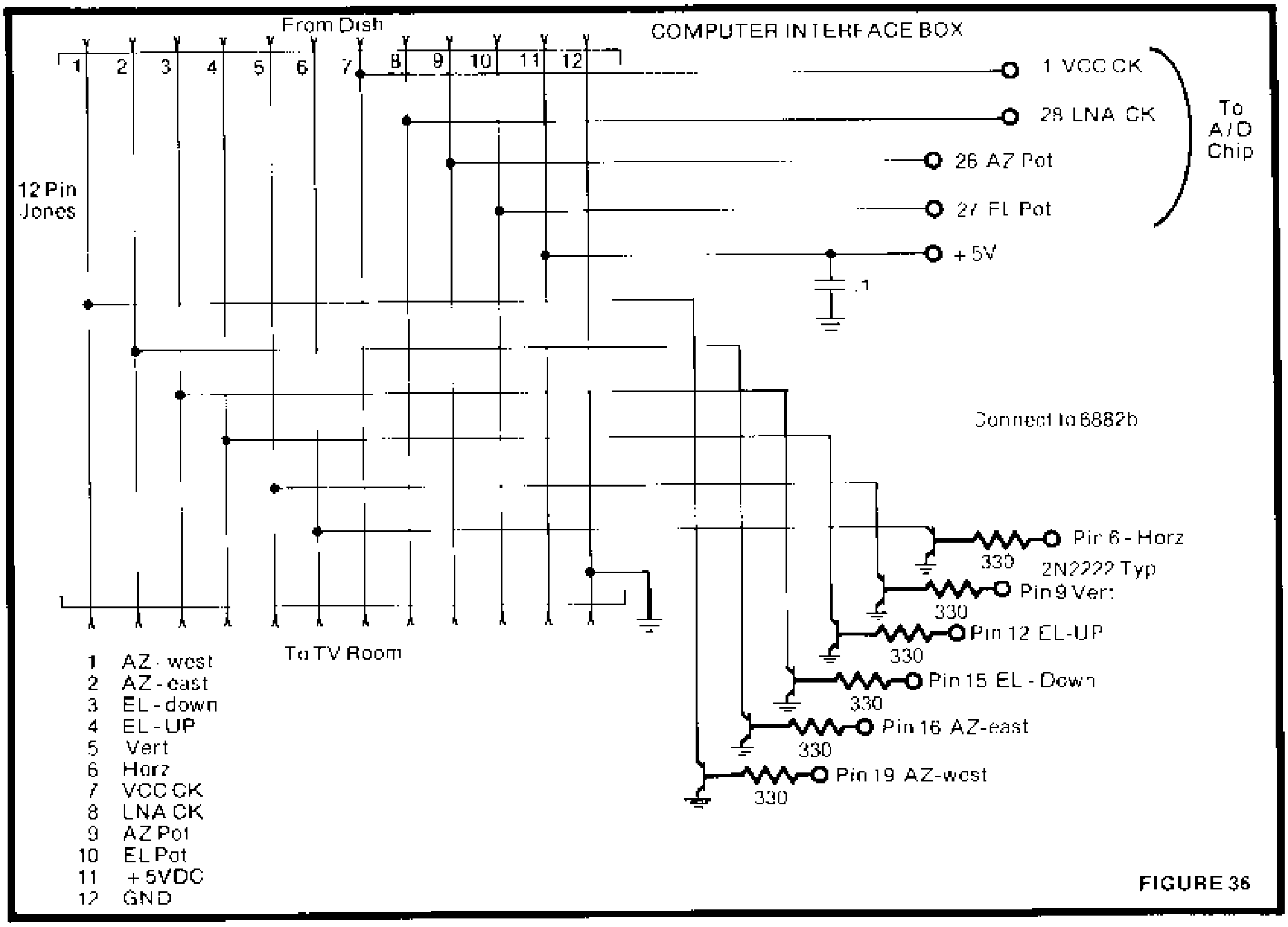


FIGURE 36

cause the program to make a decision that is wrong. Accurately converting analog pot positions to digital data can be a real hassle as we've already seen. A combination of hardware and software are necessary to get the right info.

Also the speed with which a decision may be made and a command given are several orders of magnitude greater than the ability of the hardware we control to respond. But that's a software problem we can solve in due course.

OUTPUT DATA PORTS

Like we said before, our design goal is to devise a simple interface that we can 'hang' onto our manual control lines so that we are never a slave to the computer if it just happens to go belly-up just when we want to swing over to that soccer match on Westar 2. We can install more relays to control the antenna motor lines but it would be easier to use a batch of cheapy transistors from Radio Shack at 15 cents apiece.

In figure 36, we see the transistors hanging on the relay control lines. The emitters of the transistors are grounded and the collectors are tied to each line. All that remains is to apply enough current to the base to turn on the transistor and bring the appropriate motor relay line low, thereby turning on that particular motor so long as the base gets juice. The computer can output an appropriate voltage to do the job from an output port. Since most output data ports are 8 bits wide, it is possible to hang up to 8 transistors at once on the port. That means we can control 8 things with only one port. Besides the obvious azimuth and elevation, we can rotate the feed for polarization control or even control security lights or power at the antenna.

How does computer data operate the transistors? Turning on **each bit** of the port will turn on **each transistor**. So the actual data that outputs is really a function of bit positions alone. If the 'azimuth west' motor control transistor were on the first bit, then a binary 00000001 sent to the output port would turn on that transistor. The 'azimuth east' control transistor on bit 2 could be turned on with a 00000010. Sending a binary 00000011 to the output port would turn on both east and west transistors and who knows what would happen! You can install all kinds of interlocking contacts on your relays or you can use caution on the software output bits.

ANALOG DATA INPUT PORT

Several methods can be used to read the position of your antenna into the computer. An external counter can present a BCD word to a parallel input port. By now you know the problems of this method in as much as the circuit must **remember** at all times the position of your antenna. If you shut off the power, it forgets everything. You must re-index by moving your antenna back to position 0 and resetting the counter. Or you must reprogram the counter with some extra circuitry for the position you were at last. That's easy if you were already on a satellite. You know where it is. On the other hand you might not. Edsel Murphy may have been out there push'in on your dish!

A slightly less accurate but sure-fire way is to interlock a small potentiometer to the antenna so that a change in position causes a change in resistance. As with our earlier readout methods, the resistance change can be seen as a change in voltage or frequency. We can read the voltage change with a single chip analog to digital converter. Then use the digital word we get or change it to degrees of position by scaling.

On the other hand, we can use the pot to change frequency. To calculate the change in frequency, we count the number of times the program does the twostep (a loop counter) over a period of say one cycle of the frequency. The 555 IC timer chip strikes again as an oscillator or computer controlled one-shot! It's really a poor man's A/D converter Of course the price of a typical A/D chip is hovering near $5. So the question of **how poor** you want to go is really up to you.

Consider too if you will that the A/D converter chip we use may have up to 16 inputs! Think of the possibilities. Not only can we **see** the position of the dish, but we can measure the relay supply voltage, the LNA voltage, read the signal intensity or take the LNA's temperature. Add to that the possibility of knowing the exact rotational position of the feed in degrees and the status of a few burglar alarm sensors at the antenna. You'll sleep better tonight knowing that old Edsel can't make off with your expensive LNA!

TRS-80 INTERFACING

You don't necessarily have to use the TRS-80 as your controlling computer. The interface described here is constructed in a way that will allow you to tie it to your own preferred processor. I tested mine on a S-100 IMSAI. The TRS-80 computer was chosen instead of a dedicated processor because the computer can be used for a host of other jobs when it's not turning your antenna. If you still like the dedicated box, then read **73** magazine for May 1980 where a Kim micro is used.

Getting the handy-dandy Radio Shack TRS-80 computer interfaced to your antenna drive controls is a piece of cake despite the fact Father Tandy had, no doubt, not even the faintest notion his little 'trash 80' could do it. The only real world interface that Tandy sells ties only to their products so you must be content to use someone else's generalized interface or design your own. We opted for the latter not only as a matter of convenience, but price too.

If you've read the catalog, you know that the TRS-80 is available with 2 kinds of ROM's (read only memories). The Level 1 version has a copy of Tiny Basic in it. Tiny Basic is a simple language that is ideal for learning the ABC's of computers, but not at all adequate for automated dish control. What we need then is the other version called **Level 2** which has a larger ROM and a very high level Basic language.

Of course you can use the Level 1 computer if you do all your programming in machine language. This is not recommended if you are a new comer to computers. In fact, it's not a good idea even if machine language is your 'second' language because many of the really nifty routines you might use are not in the **Level 1 ROM** and you must therefore write them yourself. Re inventing the wheel is done every day. But you can avoid it if you plunk down something over a 'C' note more for your computer and get the Level 2 lingo.

THE TRS-80 BUSS AND OTHER VEHICLES

Like most microcomputers, the TRS-80 uses a bidirectional data buss and therefore we must share its use with the memory, the display CRT and the program itself. The trick we use to get a dish to move or read it's position is to build a simple input/output port to the computer so that signals from the processor will tell the port interface circuits when to either **in**put or **out**put data.

The two port control signals from the Z80 microprocessor chip (the real guts of the TRS 80) are appropriately named **in** and **out** and are always referred to relative to the processor. Whenever the processor wants data from a device at **one** of its 256 possible ports, it simply executes an **in** command and expects to see input data on the buss. Likewise an **out** will place output data on the buss. The only trick is how the processor or the interfaces for that matter know **who** is to input or output the data. Remember we said the data buss is shared by all.

What we need is really **another buss** that tells each device if it is on call by the processor. This buss is called the address buss and it not only selects the ports we want but is also used to address all the memory in your computer. With more than 65,000 memory locations possible with a Z80, we need 16 address lines to find any memory location. But to find all 256 possible I/O port, the Z80 only needs 8 address lines. So only the lower 8 lines are needed to address a port. (Actually the port address also appears on the upper 8 lines too).

All we need to input or output data are the lower 8 address lines, the **in** and **out** signals and the data buss...and a few software routines. Sounds simple enough hardware-wise so far. Where are the hidden gotchas? Well, for one thing the **in** and **out** are negative logic. They normally hang in there at about 5 volts and drop to 0 to signal input or output. **Then** you've got a problem The TRS-80 can't input or output. It will just sit there and stare at you. You'll have the same problem if you short a data buss or address buss line. You can usually tell when you've done it because the screen will go bananas. Neat signal 'ay?

DISGUSTINGLY SIMPLE CIRCUIT

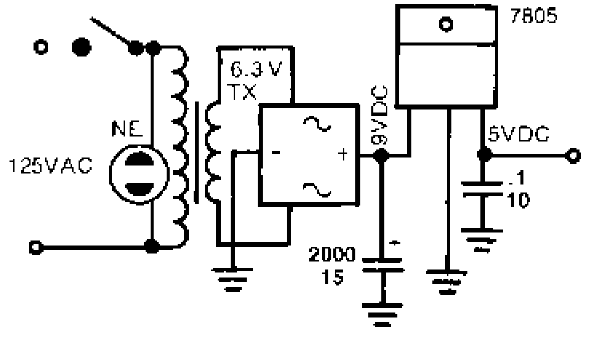
The goal is to decode a port and either input or output data to the dish drive controls. The problem is that the address buss and the data bus and the I/O commands **in** and **out** must be decoded at the **same** time. If we break the problem down into a few pieces, we can make it very easy to understand as well as finding a simple solution.

Starting first with address decoding, we need to know when the computer is calling on the dish antenna port which we must define with a number from 0 to 255 decimal.

We must be kind of careful at times when we say a number because several number systems are used when dealing with computers. This is no big deal in as much as the amounts may be the same, but the way they are represented is different. When the address buss has a zero on it, all 8 bits are 0. It looks like this as you look in: 000000000. Likewise a 255 on the buss would have the binary equivalent of 255 decimal which is 1111111 or to save time and space...port FF in the hexadecimal system. Don't worry, 255 is still 255, but the other ways of expressing a number may be more convenient when we start kicking bits around.

SO MUCH FOR THEORY

An almost infinite number of combinations of port decoding methods are possible. Every designer has his pet method The 74LS30 plus inverter plus NOR gate is often used. You see it in many commercial pieces of equipment. A variation on this method is to use the popular 8131 decoder instead of the 74LS30 because the pin positions allow you to easily apply a grounding DIP switch nearby to change addresses Very convenient as seen here in the interface board diagram, **figure 37**. We applied it here in the STT interface so that you could change or modify the interface to suit your needs You can leave out the DIP switch and just ground all the pins the switch would ground anyway. Leave out the pull-up resistors too. The software was written for an all switches closed configuration.



INTERFACE POWER

FIGURE 37A

JUST ONE OUTPUT PORT CHIP!

Remember those little transistors we wanted to turn on? We simply tie then to an MC6882B 8 bit latch, a neat chip to

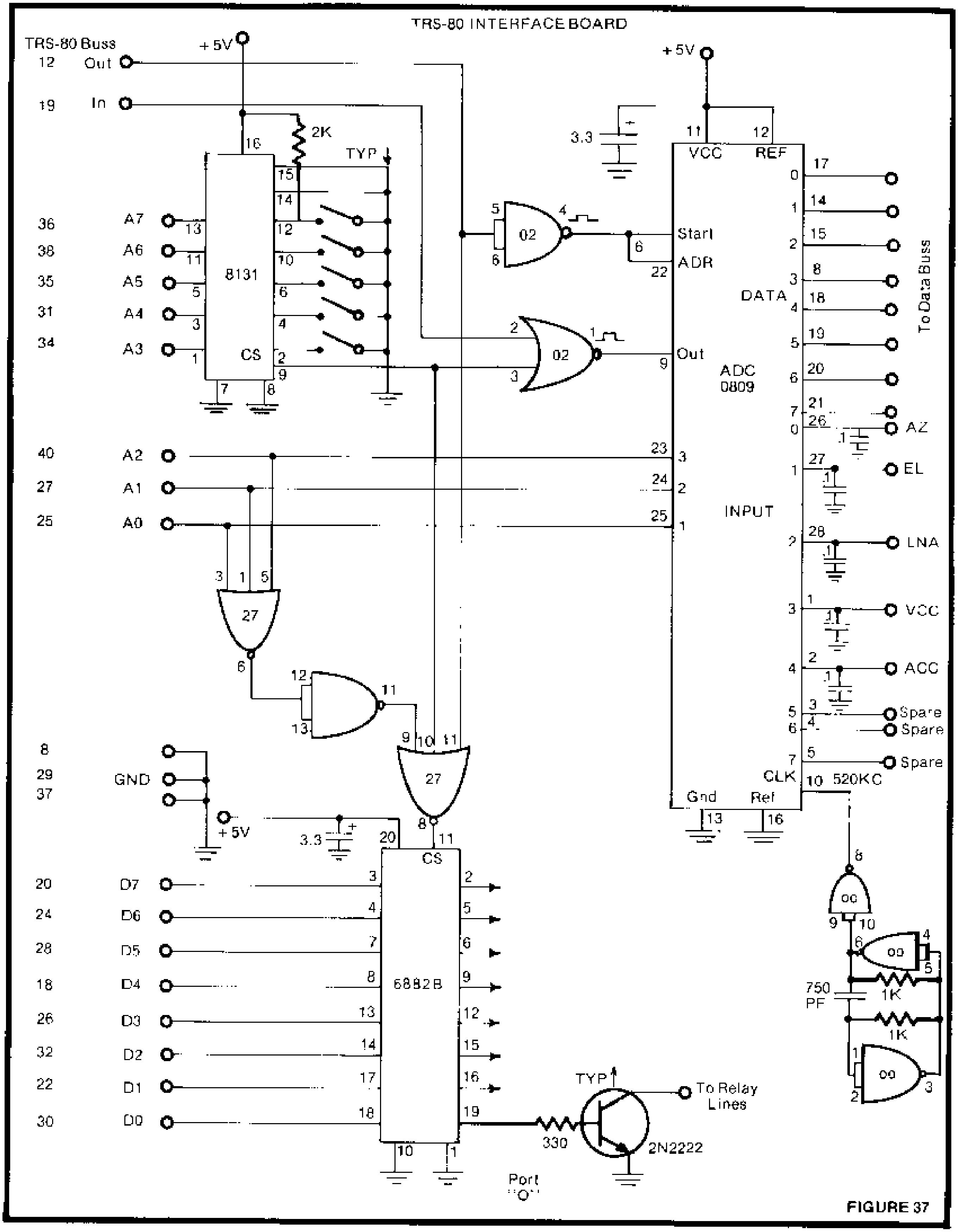

TRS-80 INTERFACE BOARD
TRS-80 Buss
12 Out
19 In
+5V
2K
TYP
16
15
14
36 A7
38 A6
35 A5
31 A4
34 A3
8131
CS
7
8
40 A2
27 A1
25 A0
27
02
02
ADC 0809
VCC
REF
Start
ADR
Out
DATA
INPUT
CLK
10 520KC
Gnd
Ref
3.3
To Data Buss
AZ
EL
LNA
VCC
ACC
Spare
Spare
Spare
.1
8 29 37 GND
+5V
3.3
20 D7
24 D6
28 D5
18 D4
26 D3
32 D2
22 D1
30 D0
6882B
CS
330
TYP
2N2222
To Relay Lines
Port "O"
00
750 PF
1K
1K

FIGURE 37

grab the data off the Z80 buss and hold it. Remember, the data we want may only be on the buss for a few microseconds. Hardly enough time to turn on the transistor let alone move your antenna. The MC6882B will grab data and make us a 'copy' of it on the output every time a chip select pulse is applied to pin 11. So whatever we send it bitwise just hangs there on the output until we change it with another select pulse. We can use the decoded port address pulse with the Z80 **out** line and call that our chip select pulse to latch all the data. The arrangement is called a parallel data output port because we can present 8 bits of data to the outside world all at the same time.

All that remains is to connect the transistors to the output through current limiting resistors and write some software to turn on each bit upon command. The resistors you chose to use should be no less than 330 ohms to keep from exceeding the ratings of the MC6882B and are wholly dependent on the beta of the transistors and the relay current they hold on. If the relay draws 100 mA and the beta of the transistor were 50, we'd simply divide the beta into the current demand to see the input current needed to turn on the transistor. In our example we'd need 2 mA. It would be a very good idea to double the current to the transistor and to use transistors with at least twice the beta since, **for bargain basement transistors**, the beta spec may be darned near anything!

The software is the easiest part. If a transistor is tied to each output port bit, then turning on that bit turns on the transistor. While you may think a computer deals with numbers, it really deals with symbols and patterns. A particular bit pattern will turn on certain bits. We use numbers as symbols to represent those patterns.

A pattern that would turn on transistor 3 represented here would have the binary pattern of 00000100 and is symbolized by the decimal number 4. If we know the number equivalent for each set of bit patterns, then programming will be a piece of cake. And if we turn on only one transistor at a time, we only need to know 8 numbers or patterns. In decimal, they are...1, 2, 4, 8, 16, 32, 64, 128. **That's all!**

Port '0' is decoded by the support chips consisting of the 8131 on address lines A3 to A7, and a 74LS27 on address lines A0 to A2. The chip select pulse from the 8131 and the **out** line are ORed with the output of the 74LS27 on A0-A2. when all these conditions 'bottom out' with the help from a lone 7400 wired as an inverter, pin 8 of the other half of the 74LS27 will go high and select the 6882B which will latch the data off the buss.

CHEAP A/D CONVERTER

National makes an inexpensive (6 bucks) A/D converter that will give us reasonable accuracy and at the same time be very simple to interface to our computer. Unlike many converters sold today, this chip (ADC0809) needs only a clock pulse train to run it. No other support chips are needed. The output is tri-stated which means we can hang it right on the TRS 80 data buss. The extra added feature of this particular converter is that it has 8 inputs! Using an internal multiplexing scheme, you can address 8 ports of analog data which is more than enough for antenna position info and LNA or controller power supply voltages. You might even have a few inputs left over for a couple of joy-sticks for games.

The clock to drive the converter is made up from a few 7400 gates tied into a simple oscillator configuration running at about 520 kHz. The output is buffered by another gate. The 3 lower address lines of the TRS-80 address buss are connected to the converter so that we can address all 8 analog ports. Remember that 3 bits can give us up to 8 combinations if we also count zero.

A single 74LS02 NOR gate wired as an inverter is used to start the A/D converter from the processor **out** line. We set the address latch within to remind it that the lower 8 bits on the address bus have the number of the input we want to convert. In as much as we must specify an address to start conversion, a convenient method is to execute an **out** to that address. It doesn't matter what we output unless an output port is tied to that address. In the STT interface, the ports are numbered 0 to 7 for input. And to save chips, port 0 is also an output port. So we must be careful (at least for port 0) to output only zeros to that port else we might move the antenna while we were trying to read it!

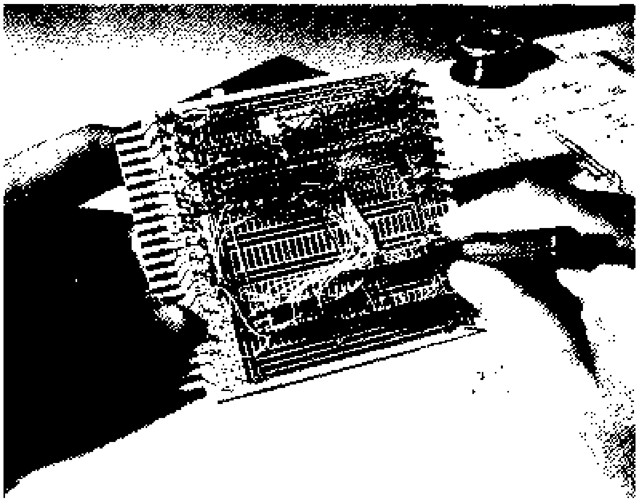
The sequence of events goes like this...the program tells the processor to output a 0 (8 zeros in parallel) to one of the analog ports. This causes the A/D to start conversion on the port selected because we gave it an address from the address buss as well as a signal to start conversion from the **out** line.

The actual conversion takes only 100 microseconds and you can either devise an elaborate scheme to signal your computer when the conversion is finished or you can wait something more than 100 microseconds in a delay loop and then read the data from the converter. If you program the converter in **basic** as we have done because of hardware speed, then the problem takes care of itself in as much as **basic** is much slower. Speed is really not important when we consider that the antenna and mechanical controls are several thousands of times slower, a point many designers overlook.

At the end of our 'period of anticipation' we input the analog data as a digital word from 0 to 255 or as bit positions go, 00000000 to 11111111. The way we do this is to address the right analog port and do an In (INP in Basic) instruction which will cause the converter to jam the data onto the buss long enough for the processor to grab it. The A/D chips are wired in a ratiometric configuration which is self-scaling. It's up to the program at that point.

CONSTRUCTION TIPS

Despite the fact you can't run A/D chip lines all over the place for fear of system crashing noise, it's possible to wirewrap the board. Consisting of only 6 chips, a wirewrap job should take very little time. If you've never tried wirewrap, you may discover it's just the ticket for quicky stuff because it's easy. All of the fixins are at Radio Shack.



WHILE WIREWRAP may look like a hodge-podge to PC board enthusiasts, it's faster and mistakes can be corrected quickly. Despite what you may think, the actual wirewrap connection has been proven to be just as good as solder in applications like this.

Mount the board on a standoff or two along with the power supply in a small metal box. Run ribbon cable to the screen printer port on your RS expansion interface or to the 40 pin buss on the rear of the computer. Keep the cable as short as possible. Two Jones jacks are mounted on the case rear to loop-through the remote box in the TV room.

INTERFACE TEST PROGRAMS

One of the nifty features of computers is the ability to program them to find problems with hardware. This is more of the philosophy we hit on before of finding ways to trade hardware problems for software solutions. Nothing beats a dual trace scope with storage for computer hardware

```
10 '**********************************************************
20 '
30 '        OUTPUT PORT '0' TESTER
40 '
50 '**********************************************************
60 ' (C)1980 STEPHEN GIBSON
70 '
80 CLS:INPUT"WANT HARDWARE TEST INFO  Y/N ";A$:IF A$="Y" THEN GOSUB 210
90 CLS:PRINT@212,"OUTPUT PORT 0 TESTER"
100 PRINT
110 PRINTTAB(5)"INPUT BIT NUMBERS 1-8 TO TEST WITH LOGIC PROBE"
120 PRINT@710,"TESTING BIT #";
130 A=VAL(INKEY$):IF A=0 THEN 130
140 IF A<1 OR A>8 THEN 10
150 PRINT@723,A;
160 IF A=1 THEN B=1 ELSE IF A=2 THEN B=2 ELSE IF A=3 THEN B=4
170 IF A=4 THEN B=8 ELSE IF A=5 THEN B=16 ELSE IF A=6 THEN B=32
180 IF A=7 THEN B=64 ELSE IF A=8 THEN B=128
190 OUT 0,B:A=VAL(INKEY$):IF A=0 THEN 190 ELSE 140
200 '
210 'HARDWARE TEST STUFF...
220 CLS:PRINT
230 PRINT"THIS PROGRAM WILL TEST ALL 8 BITS OF YOUR OUTPUT"
240 PRINT"PORT 0. PUT A LOGIC PROBE ON PIN 11 OF THE MC6882B"
250 PRINT"TO SEE IT'S ENABLE PULSE. NO LOGIC TRANSITIONS MEAN"
260 PRINT"YOU ARE NOT DECODING THE PORT. WORK YOUR WAY BACK"
270 PRINT"PAST THE 74LS27 TO SEE TRANSITIONS ON 9,10 AND 11."
280 PRINT"A DUAL TRACE SCOPE WILL TELL YOU IF 9,10 & 11 GO"
290 PRINT"LOW AT THE SAME TIME. WITHOUT A SCOPE, YOU MUST"
300 PRINT"CHECK PINS 3,4,5 FOR INPUT AND THAT THE 7400 THAT"
310 PRINT"IS WIRED AS AN INVERTER IS WORKING."
320 PRINT
330 PRINT"PUSH KEYS 1 TO 8 AND HOLD THE PROBE ON THE OUTPUT"
340 PRINT"PINS OF THE MC6882B TO TEST FOR LATCHED DATA BITS."
350 PRINT
360 INPUT"PUSH 'ENTER' TO BEGIN TEST. ";A:RETURN
370 '
380 END
```

debugging, but a logic probe and these two quicky programs will point you to the right path.

The 'Output Port O Tester' simply turns on bits at port zero. You push a number and the bit is clicked-on as long as you hold a key down The key you push is stored in variable A and displayed. Variable B is then figured by one of those **if/then/else** configurations as a 'bit position'. It is sent to port 0 in line 190. The program loops.

Handy troubleshooting data is in lines 210 to 360. **You don't really need to type them in** to make the program work.

The 'A/D Port Tester' is a loop that sends an **out** to each port to start conversion, then reads it. The ports in the interface are 0 to 7. If you are **not** using a TRS-80 computer, then the **Print @** statements may give you trouble on your display. **If** you use a serial I/O such as a Teletype, try reading one port at a time and waiting a few seconds before printing to save paper. The goal here is not to see how fast you can read 8 ports, but to determine if they are working.

You can 'gimmick' a pot into the interface with clip leads to save running out to the antenna and twisting the **real** feedback pot. Pick a resistance of about 1K and tie the slider to an input. One end should be on 5VDC and the other on ground. **Careful not to tie** the pot to the unregulated supply! As you turn the pot, the input you picked should run from 0 to 255 decimal on the screen.

As in the output port program, troubleshooting info in lines 320 to 450 should help you find any problems.

FULL COMPUTER CONTROL WITH 'AUTODISH'

The last step in our quest for the ultimate is the software. It is here that we are kind of open-ended. In fact the program listing here **isn't** finished (i.e. there is room to grow!): It can't be so long as you can think of something else you may want to do with your TVRO. The limits are dictated by the interface. With 8 on/off outputs and 8 A/D inputs, you can play for hours!

Still we need a start, a base of operation from which we can write routines to scan the skys or assist our programmable VTR to record programs on different satellites while we are away. To that end we present the **Autodish Controller Program,** a place to **begin** your own software routines.

The program is in two interlocking parts. A manual search routine which you might recognize as a mix of the A/D and

```
10  '*********************************************************
20  '
30  '           A/D PORT TESTER PROGRAM
40  '
50  '*********************************************************
60  ' (C)1980 STEPHEN GIBSON
70  '
80 CLS:INPUT"WANT HARDWARE DETAILS Y/N ";A$:IF A$="Y" THEN GOSUB 320
90 CLS:PRINT@215,"A/D PORT TESTER";
100 A$="PORT"
110 PRINT@448,A$;0;:PRINT@456,A$;1;:PRINT@464,A$;2;:PRINT@472,A$;3;
120 PRINT@480,A$;4;:PRINT@488,A$;5;:PRINT@496,A$;6;:PRINT@504,A$;7;
130 OUT 0,0:REM STARTS CONVERSION
140 PRINT@513,INP(0);:REM READS PORT
150 OUT 1,0
160 PRINT@521,INP(1);
170 OUT 2,0
180 PRINT@529,INP(2);
190 OUT 3,0
200 PRINT@537,INP(3);
210 OUT 4,0
220 PRINT@545,INP(4);
230 OUT 5,0
240 PRINT@553,INP(5);
250 OUT 6,0
260 PRINT@561,INP(6);
270 OUT 7,0
280 PRINT@569,INP(7);
290 '
300 GOTO 130 :'LOOP BACK
310 '
320 'HARWARE INFO....
330 CLS:PRINT
340 PRINT"THIS PROGRAM TESTS THE NATIONAL ADC0809CCN A/D CHIP"
350 PRINT"YOU HAVE WIRED TO INPUT PORTS 0 TO 7. TO MAKE IT WORK,"
360 PRINT"THE SOFTWARE SENDS AN 'OUT' TO THE SPECIFIC PORT TO"
370 PRINT"START CONVERSION. THEN AN 'INP' READS THE PORT AND IT"
380 PRINT"IS PRINTED. EACH A/D INPUT IS READ IN A SIMPLE LOOP."
390 PRINT
400 PRINT"TO TROUBLESHOOT, FIRST TRY A LOGIC PROBE ON PIN 6 OF"
410 PRINT"THE A/D CHIP TO SEE IF CONVERSION IS BEING INITIATED."
420 PRINT"THEN CHECK PIN 9 FOR A READ SIGNAL. LAST, LOOK AT THE"
430 PRINT"CLOCK ON PIN 10. NO LOGIC TRANSITIONS AT ANY OF THESE"
440 PRINT"POINTS WILL HELP YOU LOCATE THE TROUBLE AREA."
450 PRINT
460 INPUT"PRESS 'ENTER' TO BEGIN THE TEST ";A:RETURN
470 '
480 END
```

Output test programs. You push a key and watch the antenna move on the AZ and EL readouts. It works for testing new motors, finding satellites and writing new routines which might further linearize cheap pots so you can operate with exact degree readouts. By the way this version of the program **does not** do that in as much as it is impossible to know if **your pots act the same as mine**. Better you experiment while safe with the knowledge that this program will still work whether your test routine does or not.

The Autoseek routine is really open because it is impossible to know what motors you may use or their speed. What we've done is to drop in some ponderously slow loops to chug along at a safe pace. You can shorten them to suit.

Two common algorithms are used to find a point in the sky. Depending on speed and overshoot of the hardware, one method starts to seek in a direction and keeps going until the moment the feedback pots say you've arrived. The whole system then cuts off and you hope the inertia of motion isn't too great to keep the whole thing from moving right on past the point you were seeking. The simple way to beat the wrap is to shut-down the motors just before you hit the spot you want. Your accuracy is not too good because the 'slow down' time may vary at different spots and you could easily coast right past the bird as though it wasn't even there!

A more handy approach to the problem is to move a little and shut-down. Then wait for the hardware to stop moving and take a reading off the position pots. Depending on the reading you either go some more or quit. The method is not at all elegant and most programmers hate it for that reason. But it is simple to implement, will work in most situations, and reliability is not impaired by the hardware changing speed or the way it moves from day to day. This is the 'Simple but Stupid' method we use here.

PROGRAM SECRETS REVEALED

The program prints the header in line 70 and loads some arrays in line 120 with the satellites and their relative position as known to the pots. **The way** you get this info is to use **the manual seek routines** or the remote control box in conjunction with the cut-out pointing instruments to find each satellite visible at your location. The feedback pot readings are stored in data statements in lines 670 to 770. The format is a string name of the satellite, the azimuth info, the elevation info.

A fancier way to go would be to establish the limits of the system on each plane and let the program worry how to get there. As we said, this is the 'Simple but Stupid' technique which will get you there without frills. A branch decision is made in 160 to go to the manual seek routine. Otherwise the program falls into the Autoseek routine.

Manual seek in line 400 is a loop where the keys 1 to 8 are read and displayed. The routine calls two subroutines to read azimuth and elevation in lines 520 an 530. The subroutines send an **out instruction** to start conversion and then the port is read. Azimuth is on port 0. Eelvation is on port 1. The key values are converted to 'bit positions' and sent to the output port 0 in lines 560 and 620. The routine then loops around from 630 to 520. A **break** will stop the loop.

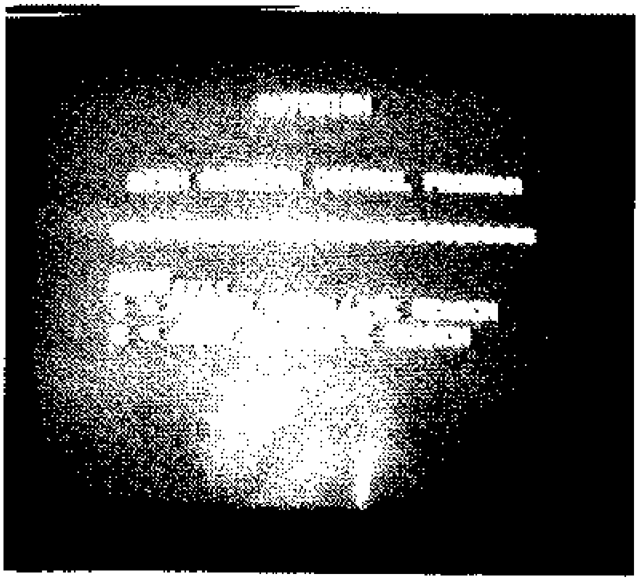
The Autoseek routine is more complex. First a list of the available satellites is displayed. 10 are displayed in this listing. To increase the amount, change the size of the **for/next loop** in line 200. If you have more than 15 satellites available, you will need to change the DIM statement in line 110. The current data statements are just examples and of course will not work for you. You must change the values and perhaps the satellites if you live somewhere other than southern California. Line 220 will test for a '0' and branch back to the menu. Otherwise the program will drop down into the actual Autoseek routine.

Autoseek is mostly a bunch of subroutines. Looking at the big picture, the program searches for the correct azimuth in line 260, then the correct elevation in line 270, prints an '**on boresight**' message and finally falls into a one line loop which updates the display by reading AZ and EL and printing them. A **break** will stop the routine.

Getting deeper into the azimuth routine, the difference between the current dish position and the satellite wanted from the array A(I) is figured in line 820 and becomes variable DI. Depending on the difference in line 860, the routine moves the dish east or west. The first bit on port 0 is azimuth west. The second bit is azimuth east.

If the difference between the current position and the position we seek is zero, we must be there, so a test is made and the routine exit is in line 850. Two other conditions are tested in lines 830 and 840. This may depend on your system, but the thought of waiting 2 or 3 minutes for the dish to move from one end of the sky to the other is too much for my patience. If the difference between the current dish position and the position we seek is greater than 20 units, we leave the motor on longer which will get us there much faster. The test is made **in line 840** and is a flag T which is set or reset. A test is made for the condition of this flag down in the motor routine at line 1050.

The other condition tested is the direction the motor must turn. My linear actuators must move a few fractions of an inch upon reversal before anything happens on the dish. A check of the sign of the difference DI will signal that the motor must unload the actuator. You may not need this feature.



REAR VIEW of computer interface box. Jones plugs loop through the control lines to the remote control box in the TV room. The very small box to the right of the CRT display and below it contains a battery and a Sonalert which is activated when the Autodish program finds boresight. Control is from the cassette port recorder control relay inside of TRS-80.

To compensate for the inertia of motion in the dish, the program waits while the dish coasts to a stop in a subroutine 1160 which is called after every move. Depending on the motors or actuators you use, this dish inertia wait timer may need to be adjusted. Your best bet is to start slow. You can then increase the speed as much as inertia permits.

As you watch how really slow your whole assembly responds, you may begin to see that **basic** as a hardware control lingo isn't so bad after all. Software speed is not a problem. As always it's the hardware!

The elevation seek routine beginning in line 920 is essentially the same but for the fact the elevation array E(I) is the source of the info and that we now concentrate on bits 3 and 4 in lines 990 and 1010 to operate the elevation motors. The motor impulse timer in lines 1040 to 1140 is all that remains of the program and is wholly dependent on the motors you use.

The duration is controlled by for/next loops in lines 1080 and 1120. A flag indicator is printed on the screen in lines 1090 and 1130.

By the way, a beeper is included in line 300 to signal you audibly that the dish is on boresight. I find this is a very useful feature when I'm in another room. The line simply closes the cassette port control relay inside the TRS-80. Tie a Sonalert to the cassette recorder control plug with a battery and...instant beeper! This is a cheap add-on bells and whistles to the program.

AREAS FOR EXPANSION

While the **autodish** may be something for the real enthusiast and perhaps a goal for your station, it is really a stepping stone or getting-off point for your own software/hardware fantasies. The extra goodies in the interface leave you a clear path to do your own thing.

VOLTAGE SCALING FOR 5V A/D

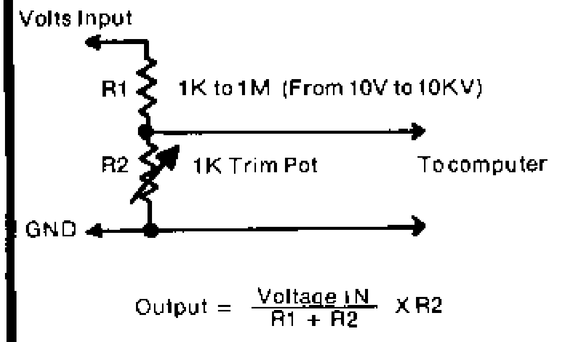
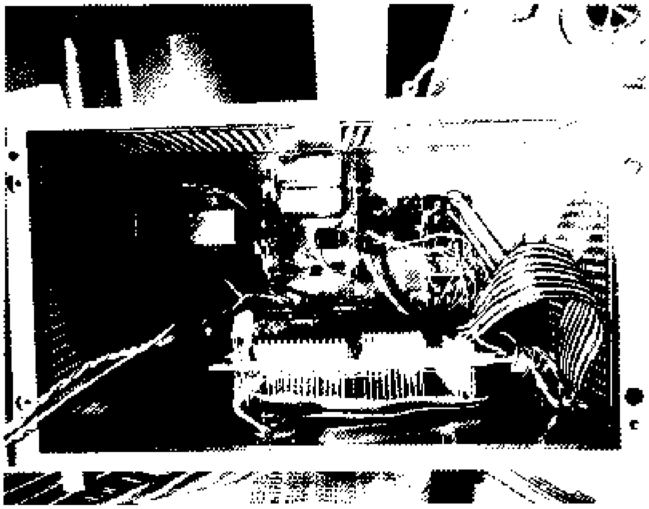

Volts Input
R1
1K to 1M (From 10V to 10KV)
R2
1K Trim Pot
To computer
GND
Output = Voltage IN / (R1 + R2) X R2

FIGURE 38

The A/D chip sees only voltages from 0-5 volts, but you can easily scale the input with a voltage divider. Knocking your brains out designing a precise divider from 1% resistors is a waste when you can save time and install a good multi-turn pot with a shaft-lock to set your standard.

A cheapy surplus trim-pot will fit almost anywhere and scaling the input numbers you get is as easy as simple division.

Autoseek is something else you might consider. Imagine that you want Satcom 2. You choose it from the program menu. But now the computer fine tunes the antenna position for maximum signal. A lot of your success at this venture will depend on your remembering to pretune the receiver to a known working transponder for the satellite you seek. Maybe your computer should do it?



THE INTERFACE BOARD is mounted on standoffs. The ribbon cable at right goes to the TRS-80 pin buss. On the back wall is the power supply and the I/O connectors that loop through to the remote control box at the TV receiver.

The paths to an algorithm for **autoseek** might first start with the idea of swinging past the bird while recording the pot position feedback, then returning to the highest reading. This action would of course have to be performed on each plane and it would be wise to repeat it several times to fine tune the position. All past pot position data would have to be saved during this operation in the unlikely event the readings dropped so you could go back to your best guess. A time limit based on the amount of data inputted should be imposed in as much as your antenna could spend **endless hours trying to find** Satcom 3!!

BEWARE THE WILD EDSEL!

Perhaps the only thing you should really worry about is the chance you may, for a moment, think like Edsel Murhpy and do something strange enough to send yourself on a wild goose chase. I hear Edsel ran off to open a hand grenade repair factory! Try to resist the temptation. Do the simple things first. Then move up to move involved projects. The end result of computer control will add that extra touch of showmanship to your TVRO, not to mention that satisfying feeling of achieving the ultimate.

```
10  '*********************************************************
15  '
20  '         AUTODISH CONTROLLER PROGRAM
25  '
30  '*********************************************************
40  ' (C)1979 STEPHEN GIBSON
50  '
60 CMD"T":'STILL THE HEARTBEAT
70 GOSUB 350 :' PRINT HEADER
80 POKE 16553,255:' FIX ROM
90 '
100 'LOAD VISIBLE SATELLITE ARRAYS
110 DIM N$(15),A(15),E(15)
120 FOR I = 1TO10 : READ N$(I),A(I),E(I) : NEXT
130 '
140 PRINT"WANT....
```

```
1 = MANUAL SATELLITE SEARCH
2 = AUTO SATELLITE SEARCH"
150 A$=INKEY$:IF A$="" THEN 150
160 IF A$="1" THEN 400 :' DO MANUAL SEEK ELSE AUTO
170 '
180 '******* AUTO SEEK ROUTINE *******
190 '
200 CLS:PRINT"CURRENT SATELLITES IN MEMORY
":FOR I = 1TO10 :PRINT I,N$(I),A(I),E(I): NEXT
210 INPUT"
WHICH  (ENTER '0' TO EXIT)"; I
220 IF I=0 THEN GOSUB 350: GOTO 140 :'HEADER AND RESTART
230 '
240 CLS:PRINT CHR$(23)"AUTO SEEKING - ";N$(I)
250 PRINT:PRINT:PRINT"AZIMUTH","ELEVATION":PRINT:PRINT:PRINT
260 GOSUB 790:' FIND AZIMUTH
270 GOSUB 920:' FIND ELEVATION
280 PRINT@704,"ON BORESIGHT!!!"
290 '
300 FOR J = 1TO100: OUT255,12 : NEXT : OUT 255,8 :' BEEPER!
310 GOSUB 1190:GOSUB 1220:PRINT@384,A,E:GOTO310:' UPDATE READINGS
320 '
330 '****** PROGRAM HEADER ROUTINE ******
340 '
350 CLS:PRINT CHR$(23)"
          AUTODISH
"
360 PRINT" DISH ANTENNA CONTROL PROGRAM":PRINT
370 PRINTSTRING$(30,"*")
380 PRINT:RETURN
390 '
400 ' ******* MANUAL SEEK ROUTINE *******
410 '
420 CLS:PRINT CHR$(23):PRINT"     MANUAL SATELLITE SEARCH"
430 PRINT:PRINTSTRING$(31,"*")
440 PRINT"      AZIMUTH","ELEVATION"
450 PRINT:PRINT:PRINT
460 PRINT"PUSH KEYS TO MOVE DISH:"
470 PRINT"1 = AZIMUTH WEST
2 = AZIMUTH EAST"
480 PRINT"3 = ELEVATION DN
4 = ELEVATION UP"
490 PRINT"5 = ROTATION IN
6 = ROTATION OUT"
500 PRINT"FUNCTION ->";
510 '
520 GOSUB 1190:'READ AZ
530 GOSUB 1220:'READ EL
540 PRINT@396,A,E;:' DISPLAY
550 PRINT@982,K;:K=PEEK(14352):IF K<1 THEN OUT 0,0:' READ KEYS
560 IF K>64 THEN OUT 0,0: K=0 : GOTO 550
570 IF K = 64 THEN OUT 0,32 :K=6:GOTO550:' TURN ON BIT 5
580 IF K = 32 THEN OUT 0,16 :K=5:GOTO550:' TURN ON BIT 4
590 IF K = 16 THEN OUT 0,8  :K=4:GOTO550:' TURN ON BIT 3
```

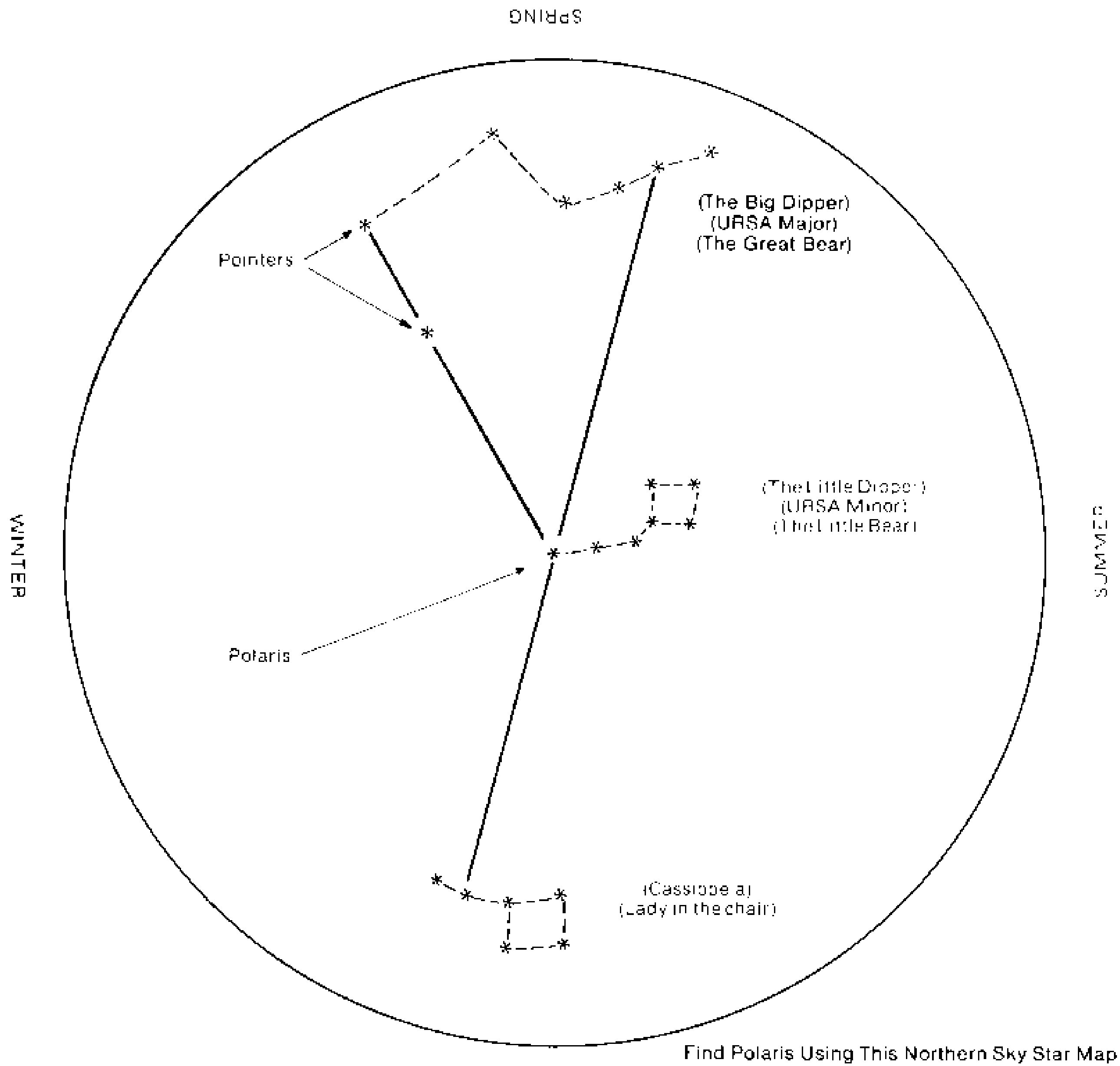
```
600 IF K = 8  THEN OUT 0,4  :K=3:GOTO550:' TURN ON BIT 2
610 IF K = 4  THEN OUT 0,2  :K=2:GOTO550:' TURN ON BIT 1
620 IF K = 2  THEN OUT 0,1  :K=1:GOTO550:' TURN ON BIT 0
630 GOTO520
640 '
650 '******** SUBROUTINES ********
660 '
670 ' EXAMPLE SATELLITE DATA YOU MUST ENTER
680 DATA "COMSTAR 3",106,81
690 DATA "WESTAR 3",112,122
700 DATA "COMSTAR 2",15,123
710 DATA "WESTAR 1",29,163
720 DATA "ANIK B",55,196
730 DATA "ANIK 3",55,196
740 DATA "SATCOM 2",76,207
750 DATA "WESTAR 2",86,201
760 DATA "COMSTAR 1",96,199
770 DATA "SATCOM 1",112,174
780 '
790 'SEEK AZIMUTH
800 GOSUB 1190:GOSUB 1220:'READ AZ & EL
810 PRINT@384,A,E;
820 DI=A(I)-A:'FIND DIFFERENCE
830 NF = SGN(DI) :' SET A MOTOR UNLOAD FLAG
840 IF ABS(DI) > 20 THEN T=1 ELSE T=0:'FLAG LONGER MOTOR RUN TIME
850 IF ABS(DI) < 1  THEN RETURN:' DONE
860 IF DI < 0 THEN 890
870 PRINT@704,"MOVING WEST";:OUT 0,1:GOSUB1040:OUT 0,0
880 GOSUB 1160: GOTO 790
890 PRINT@704,"MOVING EAST";:OUT 0,2:GOSUB1040:OUT 0,0
900 GOSUB 1160: GOTO 790
910 '
920 'SEEK ELEVATION
930 GOSUB 1190:GOSUB 1220:'READ AZ & EL
940 PRINT@384,A,E;
950 DI=E(I)-E:'FIND DIFFERENCE
960 IF ABS(DI) > 10 THEN T=1 ELSE T=0:'FLAG LONGER MOTOR RUN TIME
970 IF ABS(DI) < 1 THEN RETURN:' DONE!
980 IF DI > 0 THEN 1010 :'GO UP
990 PRINT@704,"MOVING DOWN";:OUT 0,4:GOSUB1040:OUT 0,0
1000 GOSUB 1160: GOTO 920
1010 PRINT@704,"MOVING UP   ";:OUT0,8:GOSUB1040:OUT 0,0
1020 GOSUB 1160: GOTO 920
1030 '
1040 'MOTOR IMPULSE TIMER
1050 IF T=1 THEN 1120:' LONG RUN
1060 IF NF<>OF THEN 1120 :' OTHER DIRECTION, SO UNLOAD MOTOR
1070 '
1080 FOR J = 1 TO 10 :' SHORT BURST LOOP
1090 PRINT@730,"*"; :' SHORT BURST INDICATOR
1100 NEXT : PRINT@730,"  "; : RETURN
1110 '
1120 FOR J=1TO50 :' LONG BURST LOOP
1130 PRINT@730,"**"; :' LONG BURST INDICATOR
```

```
1140 NEXT : PRINT@730," "; : OF=NF : RETURN :'RESET FLAG
1150 '
1160 'DISH MOTION INERTIA WAIT TIMER
1170 FOR J = 1 TO 800 :NEXT: RETURN
1180 '
1190 'READ AZIMUTH
1200 OUT0,0:A=INP(0):RETURN
1210 '
1220 'READ ELEVATION
1230 OUT1,0:E=INP(1):RETURN
1240 '
1250 END
```

Appendix

GEOSYNC SATELLITE DATA BASE

ATS-3	69	COMSTAR 3	87	GOES-1	75
WESTAR 3	91	WESTAR 1	99	COMSTAR 2	95
ANIK A1	104	ANIK A2	106.5	SMS-1	105
ANIK B	109	-CTS-	116	ANIK A3	114
SATCOM 2	119	COMSTAR 1	128	WESTAR 2	123.5
SATCOM 3?	132	SMS-2	135	SATCOM 1	135
ATS-6	140	STATSIONAR 10	170	ATS-1	149
INTELSAT IV F4	181	INTELSAT IV F8	186	MARISAT 2	183
STATSIONAR 7	220	-ETS-	230	-CS-	225
-BSE-	250	EKRAN 2	261	STATSIONAR T	261
EKRAN 1	261	PALAPA 1	277	STATSIONAR 6	275
STATSIONAR 1	280	MARISAT 3	287	PALAPA 2	283
INTELSAT IVA F3	297	INTELSAT IV F6	300	INTELSAT IV F1	298.6
INTELSAT IV F5	300	SYMPHONIE 1	311	STATSIONAR 5	302
STATSIONAR 9	315	INTELSAT IV F2	4	INTELSAT IV F7	1
SYMPHONIE 2	11.5	SIRIC	15	STATSIONAR 4	14
MARISAT 1	15	INTELSAT IVA F1	24.5	INTELSAT IVA F4	19.5
STATSIONAR 8	25	INTELSAT IV F3	34.5	INTELSAT IVA F2	29.5



Find Polaris Using This Northern Sky Star Map (Rotate map so that appropriate season is furthest to you).

APPENDIX B North Sky Star Map FIGURE 39

OBTAINING YOUR CUSTOM ANTENNA POINTING CHART

Each purchaser of **'The Gibson Satellite Navigator Manual'** is entitled to order, at a greatly reduced cost, one customized antenna poitning chart. This chart will show you the full geostationary orbit belt from your exact location listing antenna elevation and azimuth required for you to 'hit' the satellite belt.

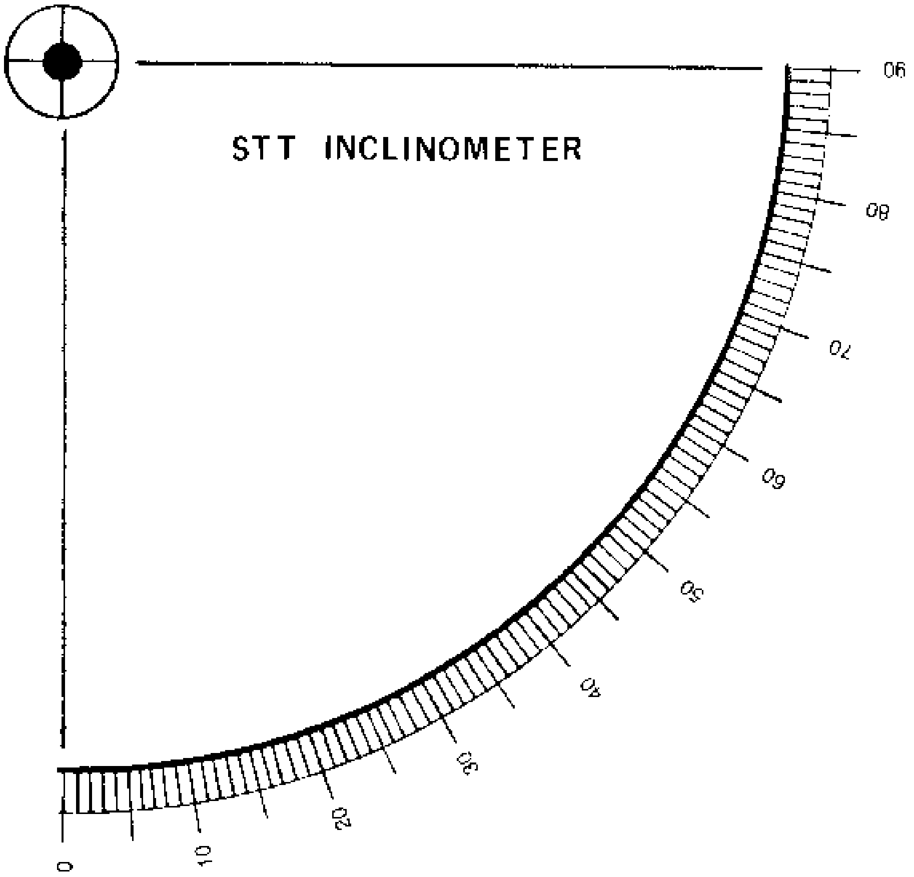
To obtain this chart, follow these steps:

1)Provide your geographic coordinates to the nearest minute (i.e. degrees and minutes) for **both** latitude and longitude. That spots where you are for the computer program.

2)If in US or possessions, send $2.00 US funds **plus** a large 13 x 10 inch envelope addressed to yourself with 28 cents US postage attached. If outside of US/possessions simply increase charge to $4 (US funds only).

3)**Mail to:** Satellite Navigation, c/o Stephen Gibson, P. O. Box 38386, Hollywood, CA 90038.

Please allow three weeks from date of mailing in US/possessions for delivery; 4 weeks outside of US.



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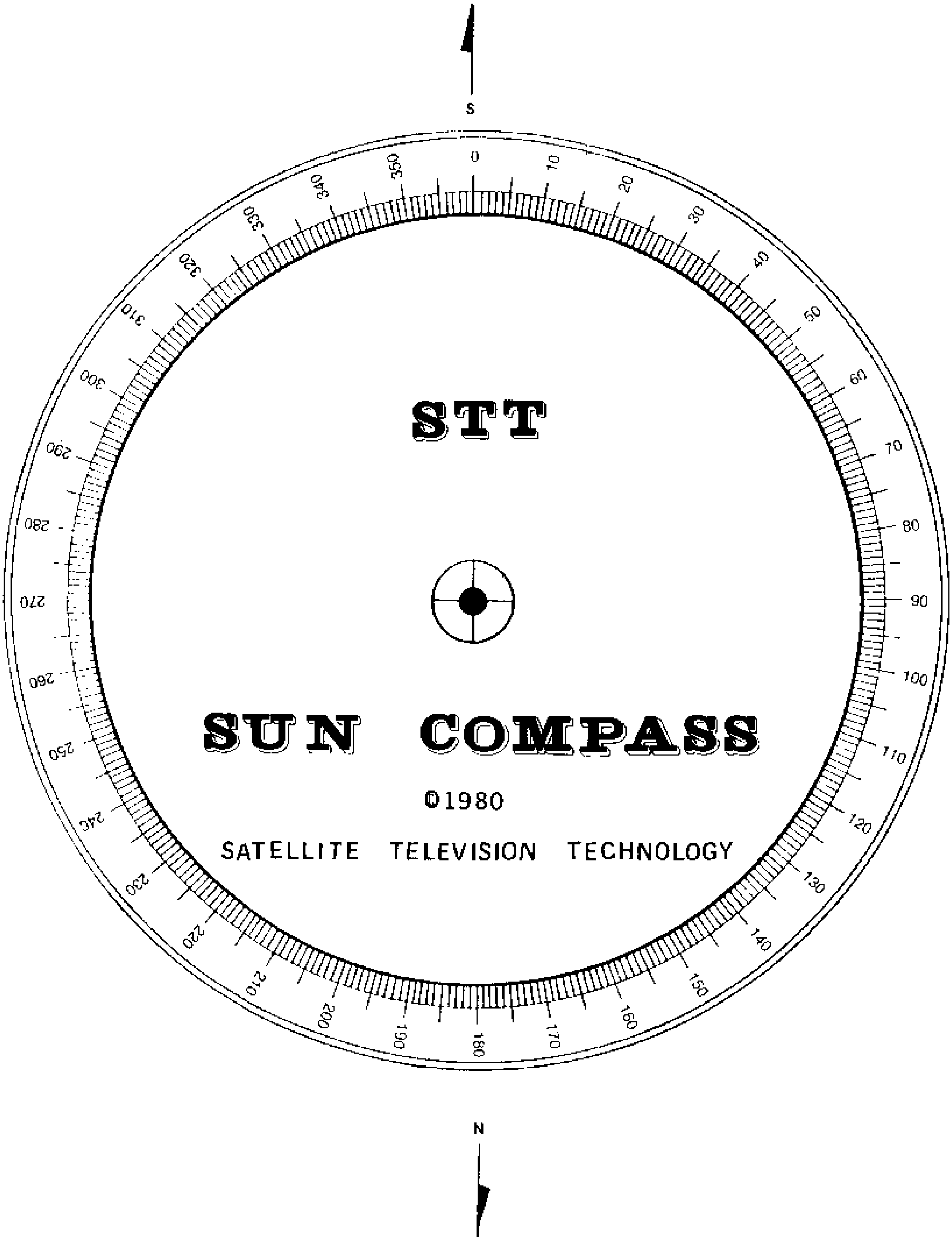
Navigation Notes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